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TAB LETTER	USAF MISHAP REPORT, CHECKLIST AND INDEX	NOT APPLICABLE	APPLICABLE NOT ATTACHED	ATTACHED
I.	FACTS			
A	AF FORM 711			X
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J	TECHNICAL OR ENGINEERING EVALUATIONS OF MATERIEL *(Department of Defense)*	X		
K	DD FORM 175 OR AUTHORIZED SUBSTITUTE FLIGHT PLAN FORMS *(See AFR 60-16)*	X		
L	DD FORM 365F, WEIGHT AND BALANCE CLEARANCE FORM F	X		
M	CERTIFICATE OF DAMAGE *(List of parts damaged)* MANHOURS REQUIRED TO REPAIR, AND COST			X
N	TRANSCRIPTS OF RECORDED COMMUNICATIONS	X		
O	ANY ADDITIONAL SUBSTANTIATING DATA REPORTS			X
P	STATEMENT OF DAMAGE TO PRIVATE PROPERTY	X		
Q	ORDERS APPOINTING INVESTIGATING BOARD			X
R	DIAGRAMS *(Fallout-impact area, etc.)*	X		
S	PHOTOGRAPHS			X
II.	BOARD OR INVESTIGATOR ANALYSIS			
T	INVESTIGATION, ANALYSIS, FINDINGS AND RECOMMENDATIONS 5 U.S.C. 552(b) (5) NOT RELEASABLE			X
U	STATEMENTS AND TESTIMONY OF WITNESSES AND PERSONS INVOLVED 5 U.S.C. 552(b) (4) & (5)	NOT RELEASABLE		X
V	REBUTTALS		NOT RELEASABLE	
W	TECHNICAL AND ENGINEERING EVALUATIONS OF MATERIEL *(Contractor)* 5 U.S.C. 552(b) (4) & (5)	NOT RELEASABLE		X
X	AF FORM 711F	X	NOT RELEASABLE	
Y	AF FORM 711G 5 U.S.C. 552(b) (5)	NOT RELEASABLE		X
Z	BOARD PROCEEDINGS 5 U.S.C. 552(b) (5)	NOT RELEASABLE		X

WHENEVER "APPLICABLE BUT NOT ATTACHED" COLUMN IS MARKED FOR ANY OF THE ABOVE ITEMS, INFORMATION MUST BE ENTERED UNDER REMARKS TO INDICATE WHAT ACTION HAS BEEN TAKEN OR WILL BE TAKEN TO OBTAIN THE REQUIRED ATTACHMENT. LETTERED TABS SHOWN ABOVE WILL BE INSERTED FOR CORRESPONDING ATTACHED ITEMS, I.E., TAB G WILL ALWAYS BE USED FOR INDIVIDUAL FLIGHT RECORDS, TAB N FOR TRANSCRIPTS OF RECORDED COMMUNICATIONS. TABS WILL BE OMITTED ON THOSE ITEMS NOT APPLICABLE.

REMARKS

AF FORM AUG 77 711h PREVIOUS EDITION IS OBSOLETE

(When filled in)

USAF MISHAP REPORT

(Fill in all spaces applicable. If additional space is needed, use additional sheet(s).)

1. DATE OF OCCURRENCE (Day, Month and Year)	2. VEHICLE(s) OR MATERIEL INVOLVED (Model designation and serial no. if applicable)	3. FOR GROUND ACCIDENTS ONLY (Base Code and Report Serial No.)
18 April 1986	Titan 34D-9	86-4-18-701

4. PLACE OF OCCURRENCE. STATE, COUNTY; DISTANCE AND DIRECTION FROM NEAREST TOWN. IF ON BASE, IDENTIFY. IF OFF BASE GIVE DISTANCE FROM NEAREST BASE.	5. HOUR AND TIME ZONE LOCAL	6.
800 Feet above Space Launch Complex 4, Vandenberg AFB CA	1045 P.S.T.	[X] DAY [ ] NIGHT [ ] DAWN [ ] DUSK

7. ORGANIZATION POSSESSING OR OWNING VEHICLE OR MATERIEL AT TIME OF MISHAP

MAJOR COMMAND	SUBCOMD OR AF	AIR DIVISION	WING	GROUP	SQ OR UNIT	NAME & BASE CODE
AFSC	SD	SAMTO	WSMC	6595 ATG		Vandenberg AFB CA (XUMV)

8. (List organizations of second vehicle, if they differ from Item 7 above)

9. ORGANIZATION AND BASE SUBMITTING REPORT (Do not abbreviate)

Titan 34D-9, Class A Space Mishap Investigation Board, HQ Air Force Systems Command, Andrews AFB, MD 20334

10. LIST OF PERSONNEL DIRECTLY INVOLVED
(See AFR 127-2 for specific instructions)

LAST NAME, FIRST NAME, MIDDLE INITIAL	GRADE	SSAN	ASSIGNED DUTY	AERO RATING	DEGREE INJURY[1] (Use Abbr)	DAYS LOST ON TT ONLY
None						

[1] *(Enter applicable letter(s) in DEGREE INJURY column. None-N; Temporary Total-TT; Permanent Partial-PP; Permanent Total-PT; Fatal-F; Missing-M)*

11. FACTUAL SUMMARY OF CIRCUMSTANCES. GIVE A DETAILED HISTORY OF FLIGHT OR CHRONOLOGICAL ORDER OF FACTS AND CIRCUMSTANCES LEADING TO THE MISHAP. THE RESULTS OF INVESTIGATION WILL BE CONTAINED IN THE "ANALYSIS PART" OF THE REPORT. ANALYSIS OF AND CONCLUSIONS DRAWN FROM ORAL OR WRITTEN STATEMENTS OBTAINED ONLY IN THE INTEREST OF MISHAP PREVENTION WILL NOT BE INCLUDED IN THIS SUMMARY.

Launch of Titan 34D-9 from Vandenberg AFB, Space Launch Complex 4 East (SLC-4E) occurred at 1845:01.110 G.M.T., 18 Apr 86. During Stage 0 ascent, the vehicle was destroyed. The vehicle had just started its programmed roll maneuver to position itself to the correct flight azimuth for its flight profile at T+7.320 seconds. Review of telemetry data indicates anomolous conditions beginning at T+8.38 seconds. Shutdown was commanded at T+15.530 seconds with command destruct occurring at T+16.38 seconds. The vehicle impacted at T+28.44 seconds. The majority of the debris fell within the confines of SLC-4E damaging Ground Support Equipment. Burning debris created many small isolated fires within 1/2-mile of the complex.

12. AUTHENTICATION

CERTIFICATION BY (Title)	TYPED NAME AND GRADE	SIGNATURE	DATE
Board President	Nathan J. Lindsay Brigadier General	[signature]	8 June 86

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- **S** Photographs

[redacted] (When filled in)

MISSILE OR SPACE VEHICLE MISHAP REPORT

(Fill in all spaces applicable. If additional space is needed, use additional sheet(s))

1. GENERAL INFORMATION

A. SERIAL NO. AND DESIGNATION OF AEROSPACE VEHICLE(S) INVOLVED	B. ASSIGNMENT OR STATUS CODE (AFR 65-110)	C. HRS. & TIME ZONE (Local) OF LAUNCH	D. DURATION OF FLIGHT HR.	MIN.	SEC.
TITAN 34D-9	6595 ATG	1045 P.S.T.	0	0	8

E. ACTIVITY OR MANEUVER PRIOR TO ACCIDENT/INCIDENT	F. ALT. OF ACDNT IN RELATION TO TERRAIN (Actual or estimated)	G. VIOLATIONS
INITIATED PROGRAMMED ROLL MANUEVER AT 7.32 SECONDS	800 FEET	[ ] YES [X] NO

2. PHASE OF OPERATION (Check one)

[ ] TRANSPORTATION [ ] HANDLING [ ] COUNTDOWN [X] INITIAL CLIMB [ ] RE-ENTRY [ ] RECOVERY [ ] OTHER (Specify)

[ ] STORAGE [ ] PRECOUNTDOWN [ ] LAUNCH [ ] INFLIGHT [ ] TERMINAL OR DIVE [ ] SERVICING OR MAINTENANCE

3. ACCIDENT TYPE (e.g. Fire or explosion on Launch or in air, intentional destruct or flight term., power failure in flight, loss of command guidance, flight control system, primary guidance system.)	4. MISSION (e.g. Launch, training, maint, handling, operations sleet, IAC Test)
EXPLOSION 8 SECONDS AFTER LAUNCH	CLASSIFIED

5. WEATHER (At time and place of mishap)

SKY CONDITIONS	VISIBILITY	WIND DIRECTION AND VELOCITY-SURFACE AND ALTITUDES ON TRAJECTORY
25,000 FEET SCATTERED	20 MILES	SURFACE - 6 KNOTS AT 350° 800 FEET - 18 KNOTS AT 320°

TEMPERATURE	HUMIDITY	DEW POINT	OTHER WEATHER CONDITIONS (If weather was a factor in accident indicate and attach a statement of weather officer)
58°F	60%	44°F	WEATHER NOT A FACTOR

6. MISSILE OR MSE DAMAGE INFORMATION

A. DAMAGE (Check one): [X] DESTROYED OR DAMAGED BEYOND ECONOMICAL REPAIR [ ] REPAIRABLE [ ] MISSING

B. EST. NO. DIRECT MANHOURS FOR REPAIR, IF APPLICABLE (Including ALC hours): N/A

COST OF DAMAGE	C. TO MISSILE (If destroyed, see T.O. 00-35-30)	D. TO OPERATIONAL GROUND EQUIPMENT (Exclude normal residual damage)
	OVER $29.8 MILLION	$ 73 MILLION

E. FIRE OCCURRED	F. EXPLOSION OCCURRED	G. T.O.'S NOT COMPLIED WITH AT TIME OF ACCIDENT
[X] YES [ ] NO IF YES, PRE-LAUNCH ___ LAUNCH ___ INFLIGHT X ON IMPACT ___	[X] YES [ ] NO IF YES, PRE-LAUNCH ___ LAUNCH ___ INFLIGHT X ON IMPACT ___	TOTAL NUMBER N/A

H. MDR SUBMITTED	I. PREVIOUS UMR'S SUBMITTED ON ANY FACTOR INVOLVED? IF YES, HOW MANY	J. FAILURE & CONSUMPTION REPORT SUBMITTED	K. TDR REQUESTED	L. DULL SWORD SUBMITTED
[ ] YES [X] NO	[ ] YES [X] NO	[ ] YES [X] NO	[ ] YES [X] NO	[ ] YES [X] NO

M. IDENTIFY REPORT NUMBERS & FACTORS ON ITEMS H, I, J, K, L AS APPLICABLE AND ATTACH REPORTS (Include Work Unit and How Malfunction Codes)

N/A

7. LAUNCH FACILITIES

A. TYPE OF FACILITY	B. IF FACILITY WAS A FACTOR IN THIS MISHAP, GIVE DETAILS
TITAN 34D SPACE LAUNCH COMPLEX 4	FACILITY NOT A FACTOR

C. SUMMARIZE LAUNCH CLEARANCE WITH MILITARY OR CIVIL AGENCIES (If applicable)	D. TOXIC CHEMICALS INVOLVED
RANGE CONTROL OFFICER MISSILE FLIGHT CONTROL OFFICER LAUNCH DIRECTOR	[X] YES [ ] NO TYPE CHEMICALS N_2O_4 UDMH

8. N/A AIRCRAFT INFORMATION

A. LAUNCH ACFT MDS	B. ACFT SERIAL NO.	C. WAS AIRCRAFT DAMAGED?	D. SPECIFY ACFT SYSTEM(S) CONTRIB. TO ACDNT IF PERTINENT (Include Work Unit and How Malfunction Codes)
		[ ] YES [ ] NO DEST. ___ SUB. ___ MINOR ___ MISSING ___	

9. N/A OTHER USAF PROPERTY DAMAGE

A. TYPE OF PROPERTY DAMAGED (Fac. Bldg. Structures & other Government Equipment)	B. REPAIR/REPLACEMENT COST
	$ ___

10. N/A NON - USAF PROPERTY DAMAGE

A. PROPERTY DAMAGE (Type and extent)	B. COST OF DAMAGE
	$ ___

AF FORM 711d PREVIOUS EDITION IS OBSOLETE [redacted] (When filled in)

11. EXPERIENCE OF KEY PERSONNEL

A. LAUNCH EXPERIENCE

DUTY (As applicable)	LAUNCHES SUPERVISED TOTAL PREV	LAUNCHES SUPERVISED THIS MISSILE	DUTY (As applicable)	LAUNCHES SUPERVISED TOTAL PREV	LAUNCHES SUPERVISED THIS MISSILE	DUTY (As applicable)	LAUNCHES SUPERVISED TOTAL PREV	LAUNCHES SUPERVISED THIS MISSILE
COMDR OF UNIT POSSESSING MISSILE		31	RANGE SAFETY OFFICER		8	LAUNCH PILOT		
FLIGHT/SITE COMMANDER		8	GROUND CONTROL OFFICER			CHASE PILOT		
OPERATIONS OFFICER			GUIDANCE OFFICER		3	OTHER ACFT CREW		
LAUNCH CONTROL OFFICER		10	OTHER GROUND PERS (Specify)					

B. OTHER EXPERIENCE: IF MISHAP DID NOT OCCUR DURING LAUNCH, IDENTIFY PERSONNEL BY DUTY AND GIVE EXPERIENCE IN TYPE OF OPERATIONS IN PROGRESS; FOR EXAMPLE, PROPELLANT LOADING, PAD SET-UP, NO. OF WEAPONS LOADINGS, ETC.

12. ENGINE(S)

A. ENGINE INVOLVED

[X] ROCKET [ ] TURBOJET [ ] SUSTAINER [ ] RAMJET [ ] VERNIER [ ] OTHER

B. NAME, ENGINE MODEL, SERIAL NO.
SOLID ROCKET MOTOR, MODEL 1206, SERIAL 122

C. MANUFACTURER AND DATE OF MANUFACTURE
UNITED TECHNOLOGIES/CHEMICAL SYSTEMS DIV.
15 OCT 81 THRU 30 JAN 82

D. ENGINE TIME (Hours, minutes) STATIC TEST, FLIGHT TEST, GROUND RUN UP
N/A

E. POWERED FLIGHT TIME ON ACCIDENT INVOLVED ENGINE (Hr, min, sec) 8.766 SECONDS

F. ENGINE TIME SINCE OVERHAUL (Hours, minutes)
N/A

G. ENGINE OVERHAUL DEPOT OR FACILITY ACCOMPLISHING TOR
N/A

13. N/A GUIDANCE OR OTHER SYSTEM(S)

A. NAME, MODEL, SERIAL NO.

B. MANUFACTURER, DATE OF MFR OF MALFUNCTIONING COMPONENT

C. TIME IN SERVICE

D. OVERHAUL DEPOT OR FACILITY ACCOMPLISHING TOR (If applicable)

A. NAME, MODEL, SERIAL NO.

B. MANUFACTURER, DATE OF MFR OF MALFUNCTIONING COMPONENT

C. TIME IN SERVICE

D. OVERHAUL DEPOT OR FACILITY ACCOMPLISHING TOR (If applicable)

14. N/A DESCRIPTION AND HISTORY OF MALFUNCTIONING COMPONENT(S)

DESCRIBE PREVIOUS DISCREPANCIES OR DIFFICULTIES ENCOUNTERED INCLUDING SERVICES, MAINTENANCE AND OPERATIONAL DIFFICULTIES. SUMMARIZE INFORMATION THAT RELATES TO SPECIFIC FAILURE(S) OR MALFUNCTION(S)

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U.S. GPO: 1980-319 [illegible]

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I GENERAL BACKGROUND

1.0 INVESTIGATION BOARD STRUCTURE

1.1 ORGANIZATION

Colonel (Brigadier General selectee) Nathan J. Lindsay was named Board President and arrived at Vandenberg AFB, CA on 19 April 1986. The board convened at Vandenberg AFB on 21 April 1986 and was organized into panels to address specific investigation issues (Figure 1.1-1). The four major panels were Propulsion, Vehicle Systems, Launch Operations and Processing, and Range Systems. Two special panels were established: one to develop and analyze a mishap "fault tree", and a second to review and analyze all films and video coverage of the flight.

1.2 METHODOLOGY

The investigation was accomplished by interviewing witnesses, reviewing procedures and hardware designs/pedigrees; analyzing range systems, photographic information, booster and payload telemetry, and reconstructed debris; and developing failure scenarios. The Propulsion panel conducted its investigation at the United Technologies Corporation Chemical Systems Division (UTC/CSD), Aerojet TechSystems Company (ATC), Rohr Industries and Marshall Space Flight Center. The Vehicle Systems panel conducted its investigation at Vandenberg AFB and Martin Marietta Company (MMC), Denver CO. The Launch Operations and Processing panel and the Range Systems panel conducted their investigations at Vandenberg AFB.

2.0 TITAN 34-D FAMILIARIZATION

The Titan 34D (T34D) space launch vehicle is the latest configuration of the Titan III family, and evolved from the Titan IIIC development of 1961 (Figure 2.0-1). The T34D configuration has a different guidance system for each of the two launch sites. An inertial guidance system and upper stage for geosynchronous or low inclination trajectory is used when missions are launched from Cape Canaveral Air Force Station, FL. The T34D is used with a radio guidance system for polar or high inclination trajectory missions launched from Vandenberg Air Force Base, California.

To date, there have been 305 Titan launches. Of these, 145 have been various models of the Titan III series. Seventy-four vehicles were of the solid rocket motor assisted configurations--TIIIC, D, E, and 34D. This mishap occurred on the ninth launch in the 16 vehicle T34D series. Seven vehicles of this model remain to be launched. There has been one other failure of a T34D vehicle, number D-7, launched from Vandenberg AFB on 28 August 1985.

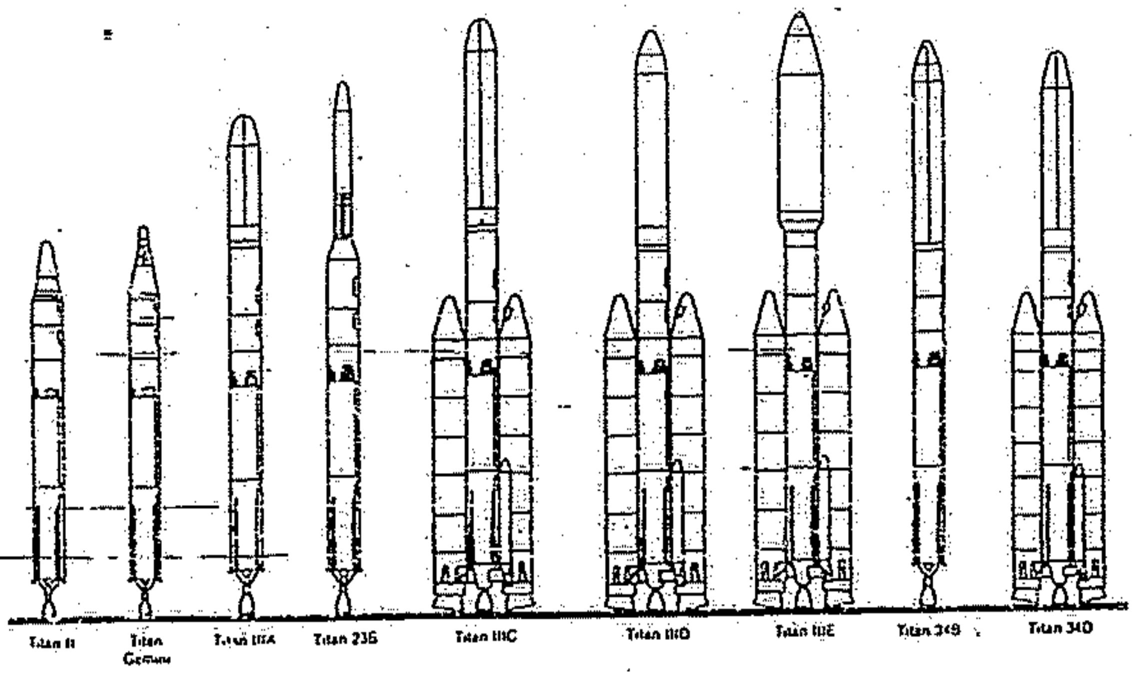
2.1 VEHICLE DESCRIPTION

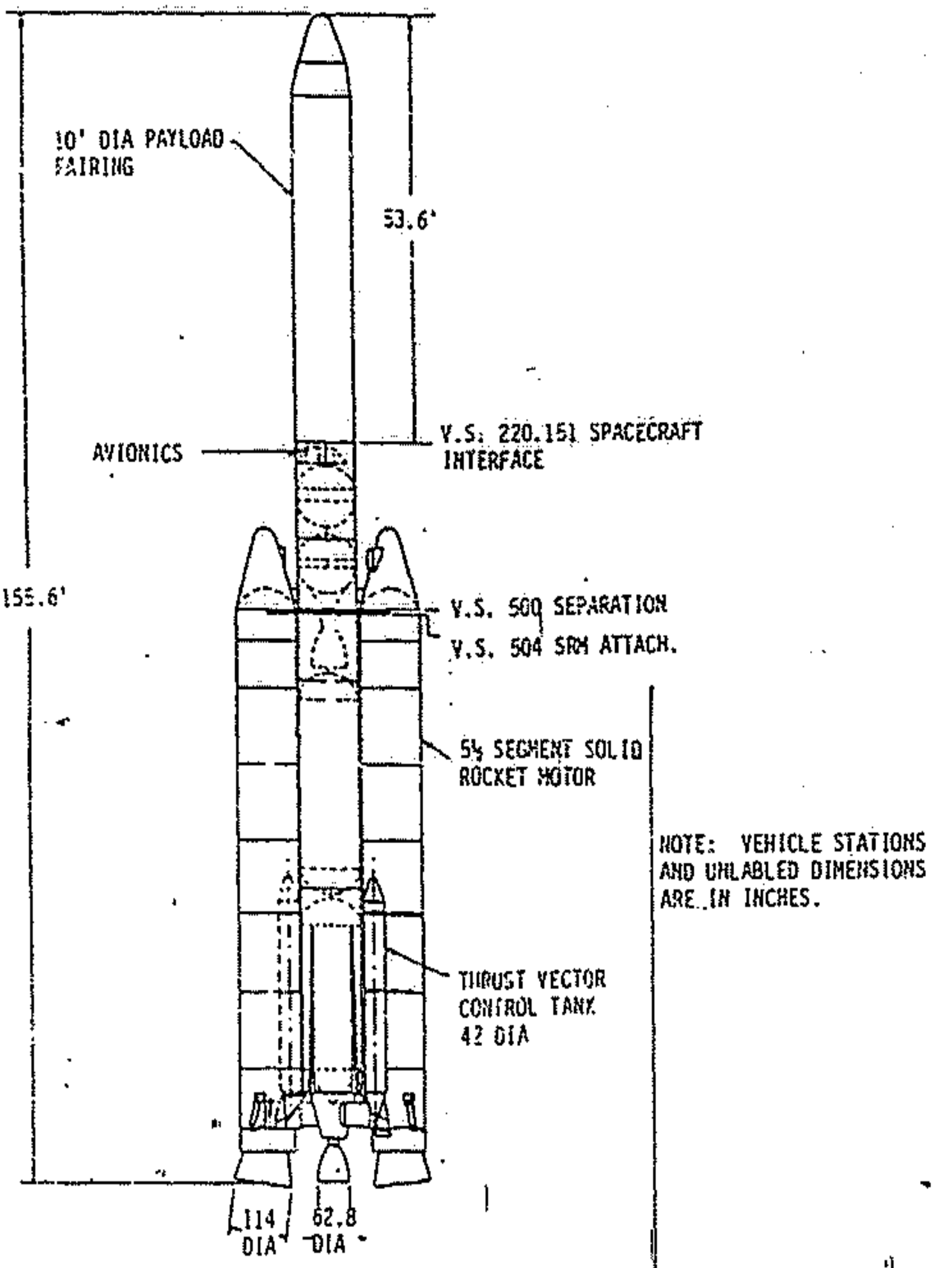
The T34D configuration includes two large solid propellant rocket motors (Stage 0) and two liquid propellant central core stages, consisting of tankage and engines (Stage I and Stage II) (Figure 2.1-1).

2.1.1 Stage 0

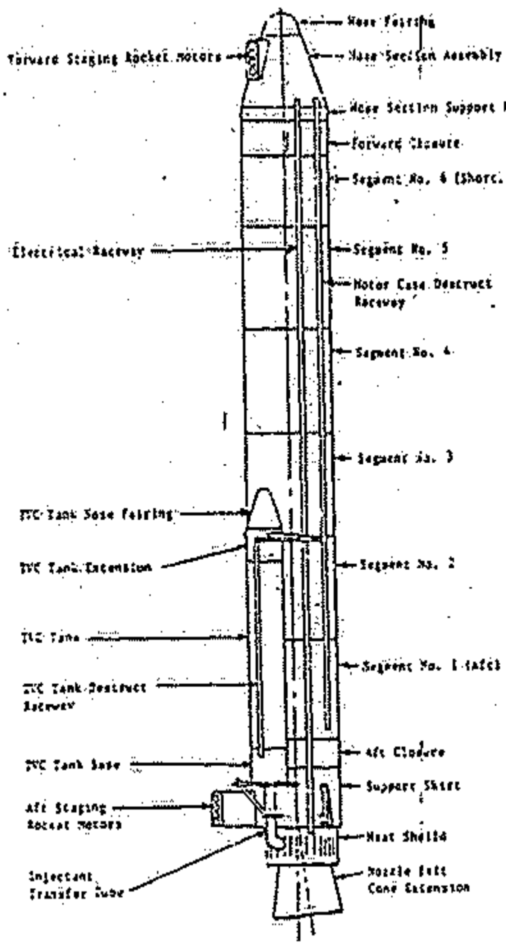
Stage 0 consists of two identical, segmented solid propellant rocket motors (SRMs) (Figure 2.1.1-1) mounted 180° apart on the central core. Each 120-inch diameter SRM is 90.4 feet long, weighs 542,700 pounds and develops 1.4 million pounds of thrust. Each motor case (pressure vessel system)

Titan Family





Titan 34D Configuration



SRM Configuration

consists of a forward closure, an aft closure, five interchangeable 126-inch long propellant segments, and a single 59-inch long propellant half-segment. Other components include the conical nozzle, forward and aft clusters of four solid propellant separation rockets, igniter, aft support skirt with heat shield, electrical/electronic distribution system for control and instrumentation, in-flight destruct system, and liquid injection thrust vector control system for steering.

2.1.1.1 The SRM segments are manufactured, without any seams, from a special tool steel (Figure 2.1.1.1-1). A single two-foot diameter steel billet is hot forged into a hollow cylinder. This cylinder is placed into a spinning drum, where the centrifugal forces press it along the drum's inner walls, increasing the length and diameter while thinning the segment walls. After cooling, the segment is placed on a steel drum on a large lathe and rolled into near final size. Final machining and heat treating produces a seamless cylinder with segment mating surfaces, without welded joints.

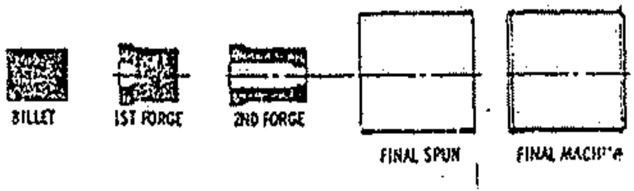
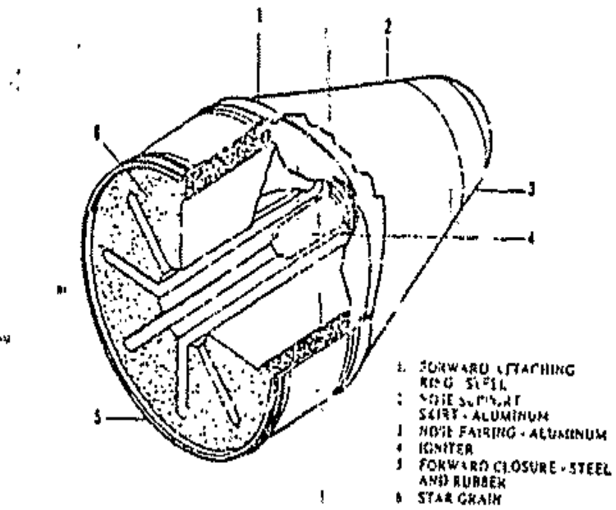


Figure 2.1.1.1-1 SRM Segment Manufacturing

2.1.1.2 The internal surface of each segment is insulated with a combination of silica-filled nitrile-butadiene rubber (NBR) and asbestos-filled NBR (Figure 2.1.1.2-1). The insulation components in each segment are the forward restrictor which prevents the forward surface of the propellant grain from igniting, the forward and aft relief boot which allows propellant shrinkage during cure to minimize stresses in the propellant and the sidewall insulation. To permit burning, the aft surface of the propellant is not insulated. The gap between the relief boot and sidewall insulation is filled with potting compound after propellant curing.

2.1.1.3 The propellant is a polybutadiene acrylic acid acrylonitrile (PBAN) composite which uses powdered aluminum fuel and ammonium perchlorate oxidizer. The plastic PBAN matrix also serves as fuel. The propellant in the six segments has a cylindrical center port which, together with the aft surface of each segment, forms the combustion surface. The forward closure, containing the gas generator type igniter, has an 8-point star internal burning grain configuration (Figure 2.1.1.3-1). The propellant is bonded to the insulation with an A1-123-26 liner which is sprayed onto the insulation before the propellant is cast.



SRM Forward Closure and Ignition System

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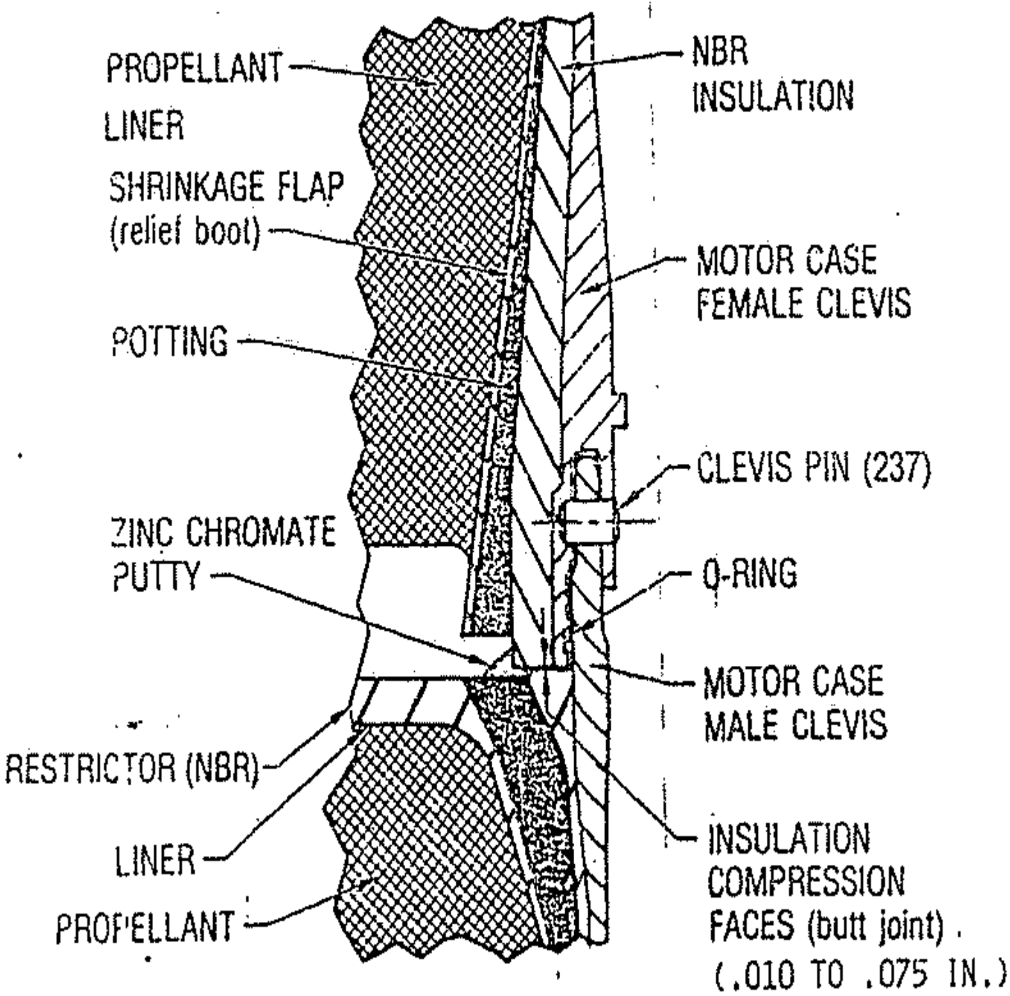


SRM Segment-to-Segment Interface

2.1.1.4 The segments and closures are joined by a pin and clevis type joint (Figure 2.1.1.2-1), each held together by 240 cylindrical pins which are inserted by hand and held in place by a retaining strap. A gas pressure seal is provided by an insulator compression joint sealed with zinc chromate putty and a back-up O-ring in the segment joint.

2.1.1.5 The SRMs produce 1.4 million pounds of thrust when ignited and operate at an initial pressure of 810 PSIA after experiencing a peak ignition pressure pulse of 875 PSIA (Figure 2.1.1.7-1).

2.1.1.6 Steering during Stage 0 operation (Figure 2.1.1.6-1) is provided by the liquid injection thrust vector control (LITVC) system which is capable of producing a vector angle of ± 5° and a maximum side force of 110,000 pounds per motor by injecting nitrogen tetroxide into the SRM nozzle through 24 electromechanical injection valves. The injection valves, operating in quadrant groups of six, are capable of being modulated from zero position to full open under guidance control from the core vehicle. Nitrogen tetroxide (N_2O_4) is provided to the valves from the TVC tank through a toroidal manifold that surrounds the nozzle. The cylindrical TVC tank, mounted externally on the SRM, is 338 inches long and 42 inches in diameter. The tank, which weighs 1113 pounds empty, carries 3421 pounds of N_2O_4 and 636 pounds of gaseous nitrogen. Initial pressure is 1050 PSIA and the system operates in a blowdown mode throughout the SRM mission.

2.1.1.7 Stage 0 operation is started with the receipt of the Fire Command, firing a pyrotechnic squib device and igniting the solid propellant igniter. The igniter burns for approximately one second, filling the main propellant grain bore with hot gas, igniting its propellent. The propellant burns along the entire central part of the SRM and on the aft end of each segment where a propellant burning surface is exposed (the forward facing surface is protected by a restrictor to prevent burning). The 8-point star grain in the forward closure ensures sufficient surface area for ignition. The SRM has a regressive thrust-time history (Figure 2.1.1.7-1), produced in part by the star configuration of the propellant grain in the forward closure. During the early phases of burning, this portion contributes much of the gas flow necessary to produce the high initial peak in the thrust-time curve. The design of the tapered bores and the forward restrictor in the individual segments provides a controlled burn of the propellant and ensures a predictable tail-off of thrust. The burn rate cannot be throttled and the engine burns until the propellant is depleted.

During the two minutes of SRM operation, the nominal sequence of events is as follows:

T-0:	SRM ignition.
T+400 ms:	Lift-off.
T+500 ms:	SRM chamber pressure peak at 880 PSIA. Maximum thrust is achieved.
T+6 sec:	Vehicle begins a roll manuever to the flight azimuth.
T+10 sec:	Vehicle begins a pitch manuever aiming itself down range.
T+55 sec:	Maximum aerodynamic pressure occurs.
T+63 sec:	Forward closure propellant is consumed, leaving propellant burning in the segments and aft closures of both boosters.
T+82 sec:	Aft closure propellant is consumed.

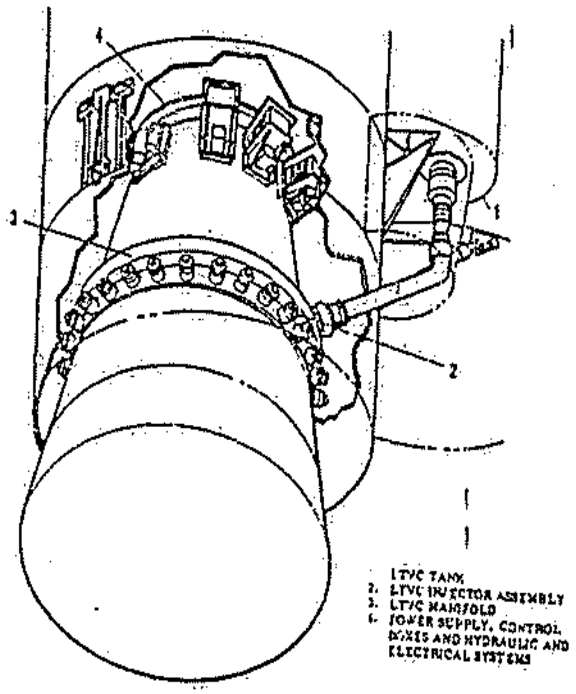
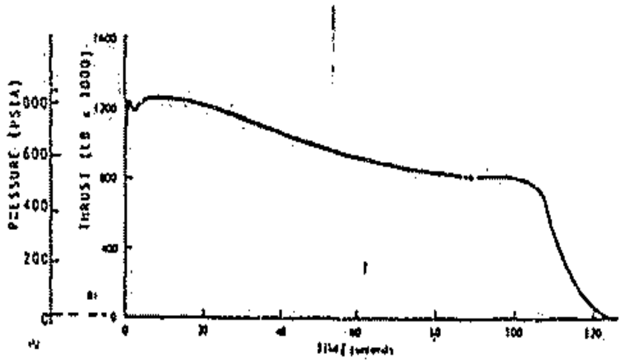


Figure 2.1.1.6-1 . Thrust Vector Control System



SRM Thrust/Pressure Profile

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T+102 sec: End of web action time is reached, and the motors are tailing off. Approximately 17,000 lbs of solid propellant remains in each motor.

T+110 sec: The Titan core vehicle senses decrease in vehicle acceleration initiating the ignition of the Stage 1 engines and a ten second countdown for solid motor separation.

T+120 sec: Explosive bolts release the forward outriggers and the aft attachment fittings which connect the solid rocket motors to the core vehicle. Staging rockets, four forward and four aft on each booster, fire and push the spent solid rocket motor away from the core.

2.1.2 Stage I

Stage I consists of a liquid propellant rocket engine attached to an airframe which includes the fuel and oxidizer tanks, between tank structure, forward skirt and aft skirt (Figure 2.1.2-1). The Stage I engine is mounted on a single frame and configured as a single propulsion unit consisting of two independently operating thrust chambers and their respective turbine-driven pump assemblies. The Stage 1 engine develops a total of 529,000 pounds (vacuum) thrust. The fuel and oxidizer tanks are welded structures consisting of a forward dome, barrel section and aft dome. They are mounted in tandem with the oxidizer tank located above the fuel tank. The fuel tank has an internal conduit to duct the oxidizer to the rocket engine. The between-tank structure and the skirts have welded frames to which the aerodynamic surface is riveted. A "boattail" heat shield of aluminum encloses the Stage I engine components to protect them from the radiant heat produced by the exhaust plume of the Stage 0 rocket motor. Thrust vector control is accomplished by gimballing the engine thrust chamber to provide pitch, yaw, and roll corrections. Hydraulic actuators, driven from the engine turbopump and controlled by electrical signals from the guidance and flight control system, provide the gimbal force.

2.1.3 Stage II

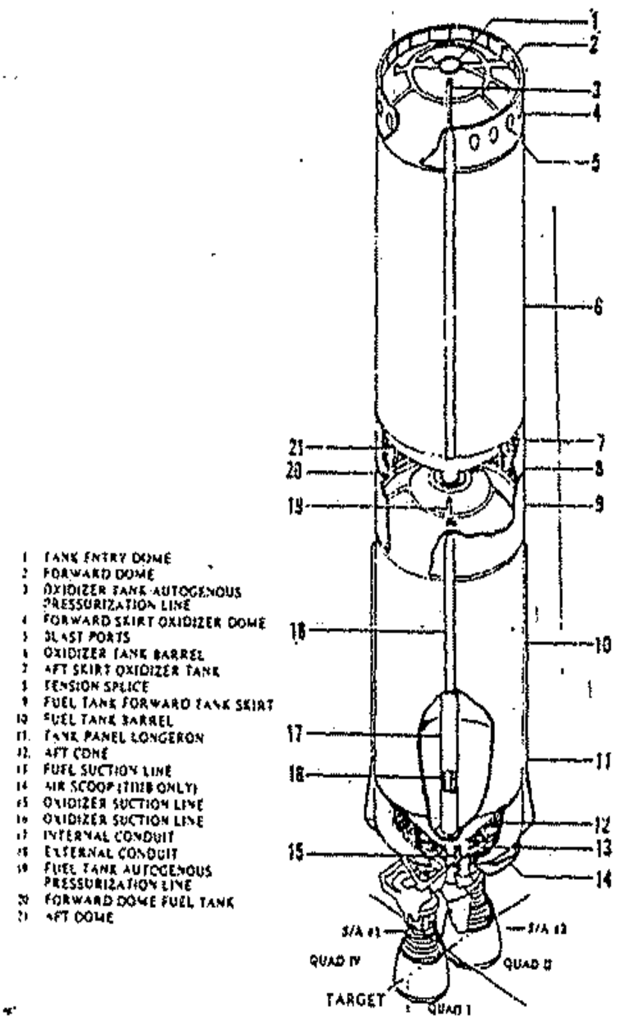
Stage II uses a single liquid propellant rocket engine attached to an airframe and is similar in construction to Stage I. The rocket engine delivers 100,000 pounds of thrust (vacuum) using one thrust chamber and nozzle and is smaller than a single Stage I thrust chamber. Thrust vector control is accomplished by gimballing the chamber, but roll control, which is impossible using only one nozzle, is provided by ducting pump turbine exhaust through a swiveled nozzle.

The Stage II airframe consists of a transition assembly for attachment of an upper stage or payload, oxidizer tank, between-tank structure, fuel tank, and aft skirt. An interstage stucture connects Stages I and II. Since Stage I shutdown and Stage II ignition are simultaneous, blast ports are provided in the interstage structure to relieve gas pressure in the Stage II engine compartment during the period between Stage II ignition and physical stage separation. The interstage structure is made from aluminum skin riveted to a welded frame. The Stage II propellant tanks are similar in structure to those of Stage I.

2.1.4 Destruct System

The T34D destruct system (Figure 2.1.4-1) causes flight termination through destruction of the vehicle when directed by the Range Safety Officer (RSO) or by the on-board Inadvertent Separation Destruct System (ISDS). High explosive destruct wafers are located between the Stage I and Stage II fuel and oxidizer tanks and linear shape charge on the SRMs.

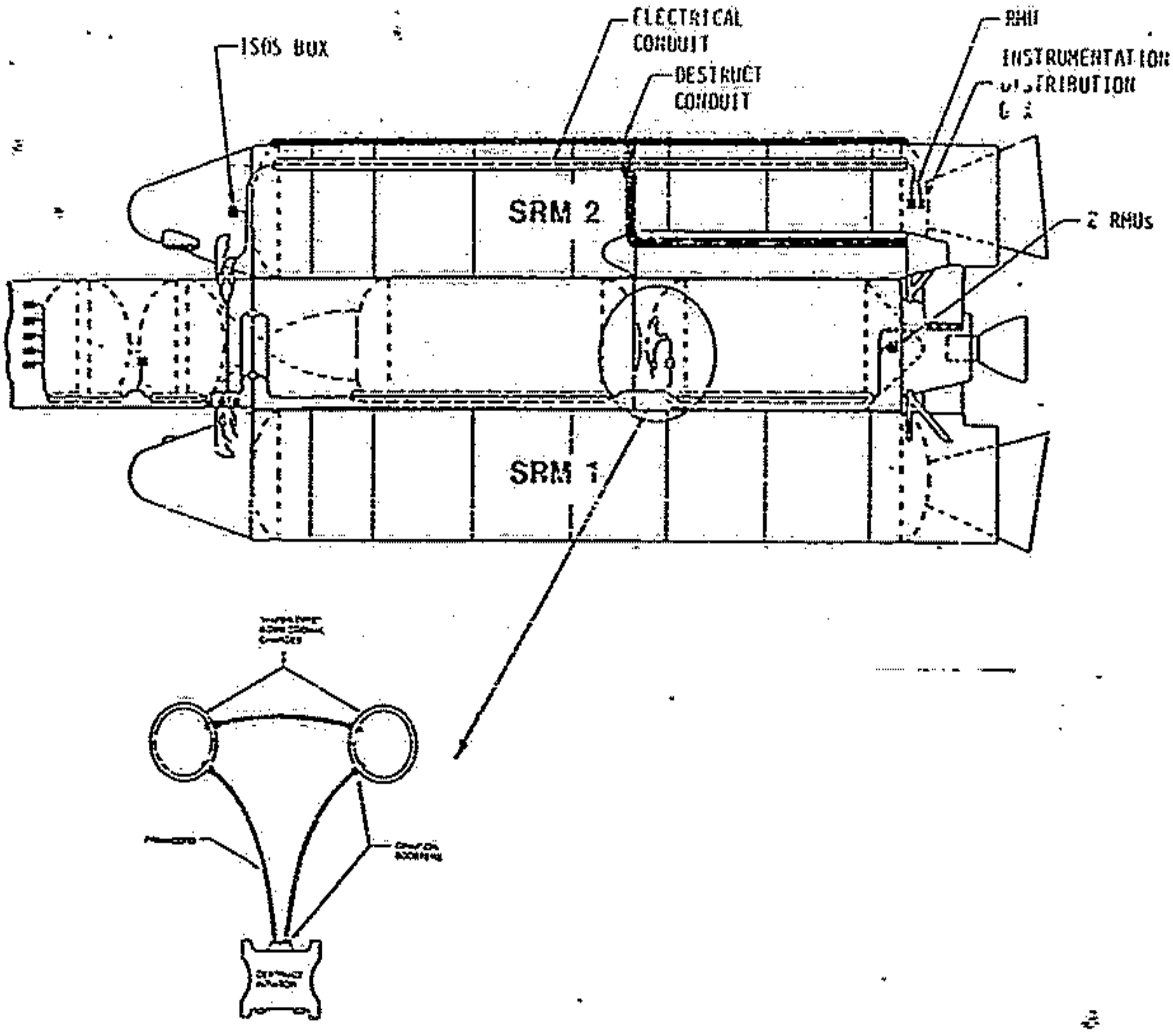
The ISDS is a safety feature intended to destroy Stage I or the SRMs in case of premature separation. It is located on both Stage I and the SRMs and ties directly into the destruct package. An ISDS is not needed on Stage II since the command destruct receivers, which are on Stage II, may be utilized to destroy this stage after an inadvertent separation.



Core Vehicle Configuration

2.1.4.1 Each core destruct package consists of an initiator, three legs of ordnance primacord circuitry with boosters, and two bidirectional destruct charges. (Figure 2.1.4-1)

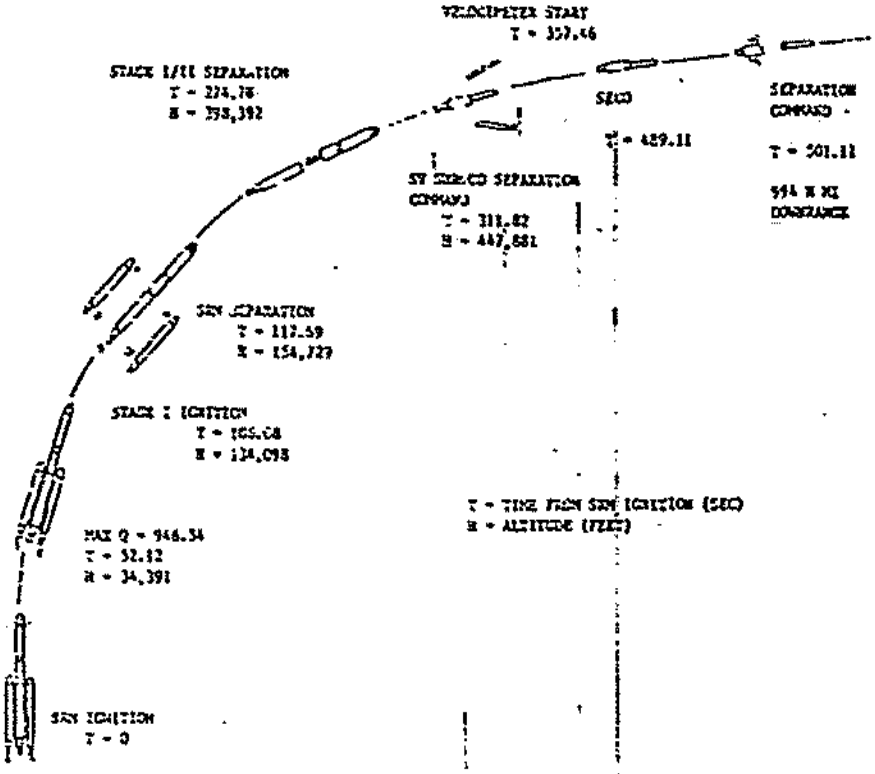
2.1.4.2 The SRM ISDS is a "hot-wire" activated, electronic system that requires the loss (breaking) of redundant hot wires and safety ground wires between the SRM and the core vehicle prior to activation. The destruct system consists of a linear shaped charge that splits each metal case segment down its length, jumpers to conduct the shock wave across segment interfaces, a linear shaped charge to split the thrust vector control (TVC) tanks, and a jumper to connect the main SRM charge to the TVC tank (Figure 2.1.4-1). The primary function of the SRM ISDS is to activate destruct in the event that the command link is lost due to premature separation of the SRM from the core vehicle. The ISDS is disabled prior to normal separation of the SRMs on command from the core vehicle.



T34D Destruct System

2.1.5 Flight Profile

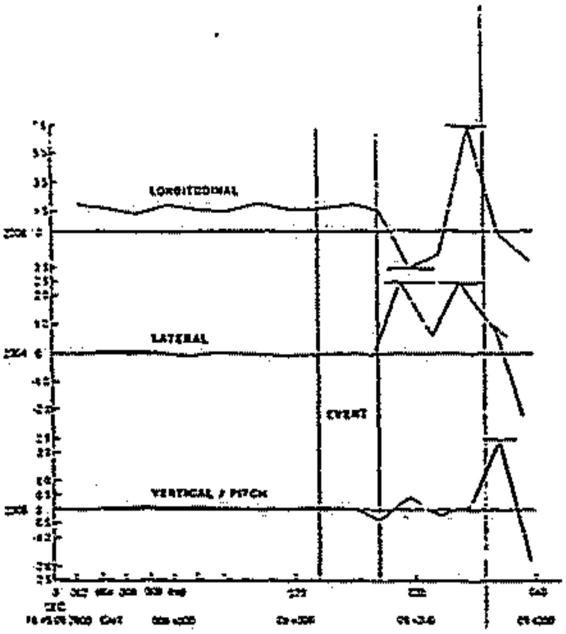
The flight profile, typical of the T34D launches from Vandenberg AFB, is depicted in (Figure 2.1.5-1). The profile shows the normal events from lift-off to payload separation.



T34D Flight Profile

2.1.6 Vehicle Guidance

For launches from Vandenberg AFB, the T34D uses a combination of an on-board, preprogrammed, open-loop guidance system and ground-based radio guidance. The on-board computer's preprogrammed "path" contains a nominal flight profile, while the ground guidance corrects for vehicle performance dispersions. Stage II contains the Titan's flight computer, three axis attitude reference (TARS) package and airborne radio guidance system receiver and beacon.



Vehicle Accelerometer Data

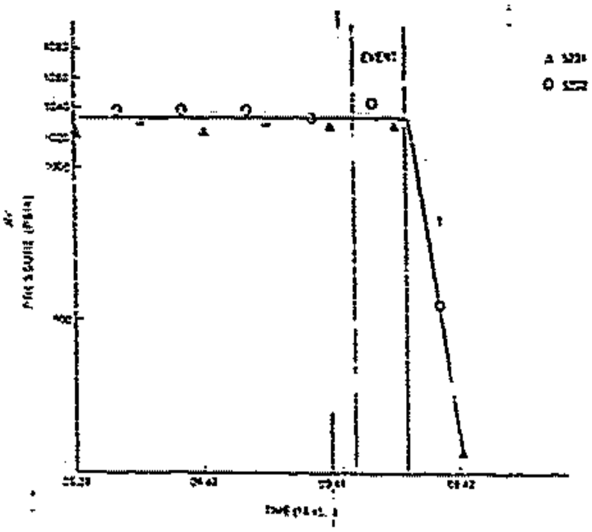
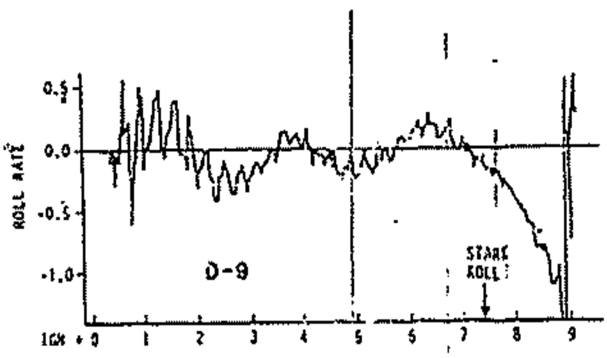
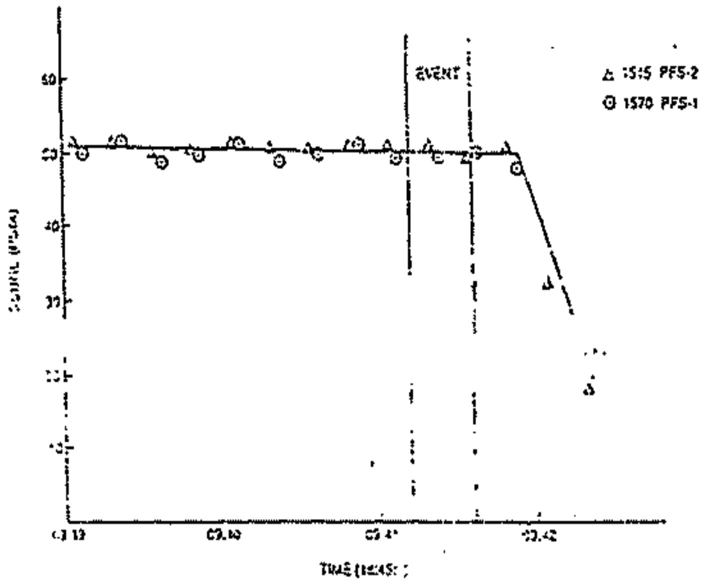


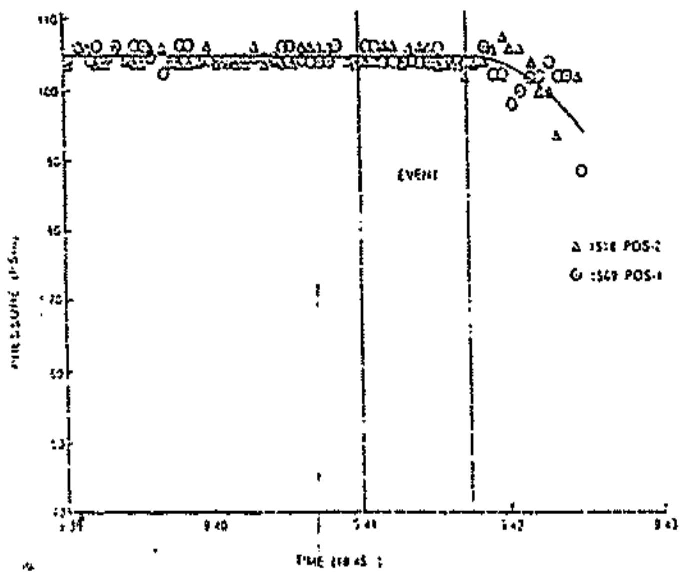
Figure 2.3-3 SRM-2 Manifold Pressure



Payload Roll Rate Data



STAGE I FUEL SUCTION PRESSURE

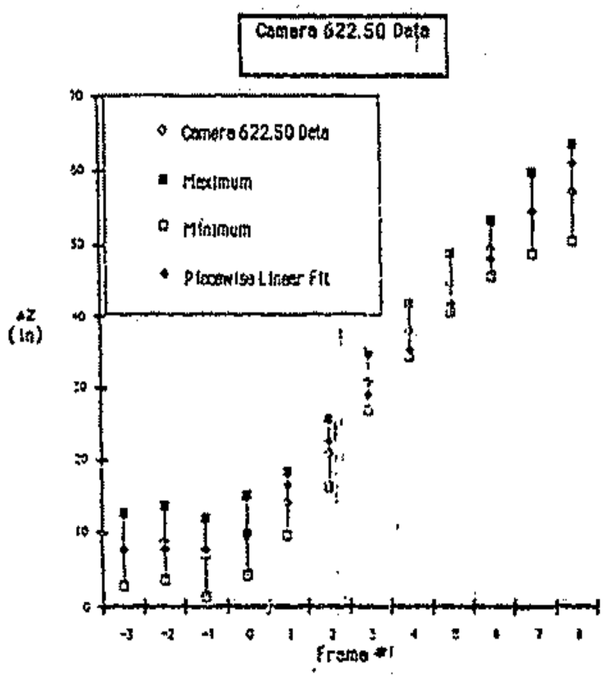


STAGE I OXIDIZER SUCTION PRESSURE

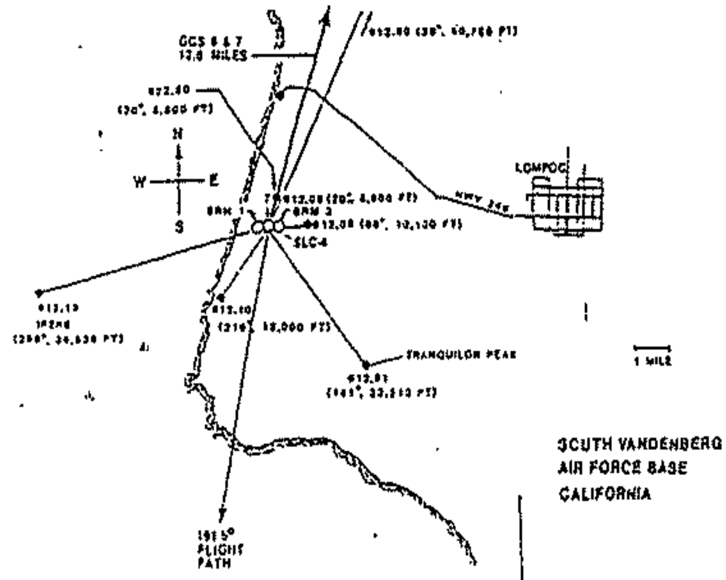
Fuel/Oxidizer Pressure

TIME				EVENT	SOURCE	COMMENT
GMT	R/L	T+	Uncertainty(ms)			
15:45:00.650	47.0	0.0	+4/-0 ±1.3	SRM Ignition	TM / Photos	Nominal
:01.110	47.460	0.460	"	Liftoff	TM (1C18) / Photos	Nominal
:01.243	47.593	0.593	"	Umbilical Disconnect	TM (1C18) / Photos	Nominal
[illegible]	[illegible]	[illegible]	-40/+0	Roll Signature Differs from D-4	P/L Roll Gyro TM	Unanticipated Roll (?)
[illegible]	[illegible]	[illegible]	±20	Change in Automatic Frequency Control (AFC)	AT&T Ground Guidance Data	Unanticipated Change in AFC
[illegible]	[illegible]	[illegible]	-10/+0	Programmed Roll Out	TM	Nominal
[illegible]	[illegible]	[illegible]	-3/+0 -5/+0	Vehicle Programmed Roll Begins ([illegible])	P/L Roll Gyro TM Booster TM	Expected Change in Roll Rate
[illegible]	[illegible]	[illegible]	±33.5	Plume Flash Observed	Film	First Visible Evidence of Explosion ([illegible])
[illegible]		[illegible]	-2.3/+0 -1/+0	STC 1 Vert accel ([illegible]) Disturbance	TM	[illegible] pitch
[illegible]		[illegible]	-5/+0 -4/+0	SRM2 Injectant Manifold Press #2 ([illegible]) Decreases	TM	Pressure drops from 1030 to [illegible] PSIA
[illegible]		[illegible]	-5/+0 -1/+0	Large change in Roll Rate ([illegible])	TM	Data shows large change in roll rate (large probably TM, magnitude questionable)
[illegible]		[illegible]	-2.5/+0 -1/+0	Fuel Suction Pressure ([illegible]) Drops ([illegible])	TM	Fuel Pressure drops from [illegible] to [illegible] PSIA
[illegible]		[illegible]	-2.5/+0 -1/+0	STC 1 Lateral Accel ([illegible]) Saturates	TM	[illegible] yaw
[illegible]		[illegible]	-1.3/+0 -1/+0	STC 1 Long Accel ([illegible]) Saturates	TM	[illegible]
[illegible]		[illegible]	"	STC 1 Vert Accel ([illegible]) Change ([illegible])	TM	[illegible]
[illegible]		[illegible]	-5/+0 -4/+0	SRM2 Injectant Manifold Press #1 ([illegible]) Decreases	TM	Pressure drops from [illegible] to [illegible] PSIA
[illegible]		[illegible]	[illegible]	Fuel Suction Pressure ([illegible]) Drops ([illegible])	TM	Fuel Pressure drops from [illegible] to [illegible] PSIA
[illegible]		[illegible]	[illegible]	1st Indication of shorted data lines ([illegible])	TM	Step data in data imply shorts in TM harness
[illegible]		[illegible]	[illegible]	Short Cleared ([illegible])	TM	TM returns to normal
[illegible]		[illegible]	[illegible]	SRM2 TM lines open ([illegible])	TM	Data slowly tracking previous sample (due to line capacitance)
[illegible]		[illegible]	-1/+0	[illegible] ms period - all data appears bad	TM	Apparent line shorts in TM data
[illegible]		[illegible]	-0.6/+0 -1/+0	Oxidizer Suction Press ([illegible]) Drops	TM	Ox Pressure drops from
[illegible]		[illegible]	-1.25/+0 +1/+0	Perturbations on SRM2 Destruct Voltages ([illegible])	TM	
[illegible]		[illegible]	-1.25/+0	Stage I Electrical Disconnect	TM	Loss of Stage I TM
[illegible]		[illegible]		1st [illegible] appear	Film	TVC [illegible] ruptured (?)
[illegible]		[illegible]		SRM2 [illegible]	Film	[illegible] begins (?)
[illegible]		[illegible]		[illegible]	Film	
[illegible]		[illegible]		STC? Ox Cloud appears	Film	STC Ox tank ruptured
[illegible]		[illegible]		SRM [illegible]	Film	[illegible] Separation [illegible] Sys operates
[illegible]		[illegible]		STC? Ox Cloud appears	Film	STC? Ox tank ruptured
[illegible]		[illegible]		Commanded Shutdown	Range	
[illegible]		[illegible]		Command Destruct	Range	
[illegible]		[illegible]		Loss of Signal (Total Breakup, hits ground)	Range, AT&T	Total loss of guidance signal, TM from Booster & P/L

Flight Timeline



SRM-2 Nose Motion History



Camera Locations

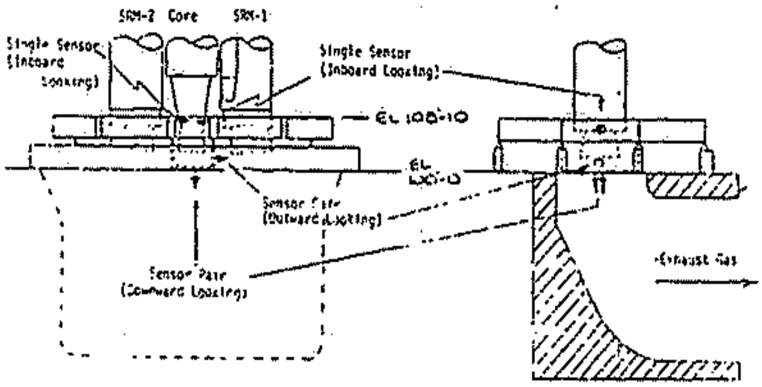


Figure 1.2.2.1-1 Sensor Locations (Boattail)

	T390-9	ETR	DESIGN
PRESSURE BAFFLE BASE (MEAS. P17A)	+3.5, -2.0*	+8.2, - 3.1 (TIIIE-05)	+11.75, - 4.36
PRESSURE BAFFLE SIDE SENSING PORT TOWARD SRM (MEAS. P19)	MEASUREMENT* DRIFTED	+3.7, - 2.0 (TIIIE-05)	
INSIDE BAFFLE SENSING (MEAS. P23, P25)	+1.35, -0.6	NO COMPARABLE DATA	BASE +3.22, -1.61 TOP +2.35, -1.18
INSIDE BOATTAIL (AIRBORNE MEAS. 2300)	+0.73, -0.56	NO COMPARABLE DATA	+1.66 ESTIMATED FROM VENTING ANALYSIS

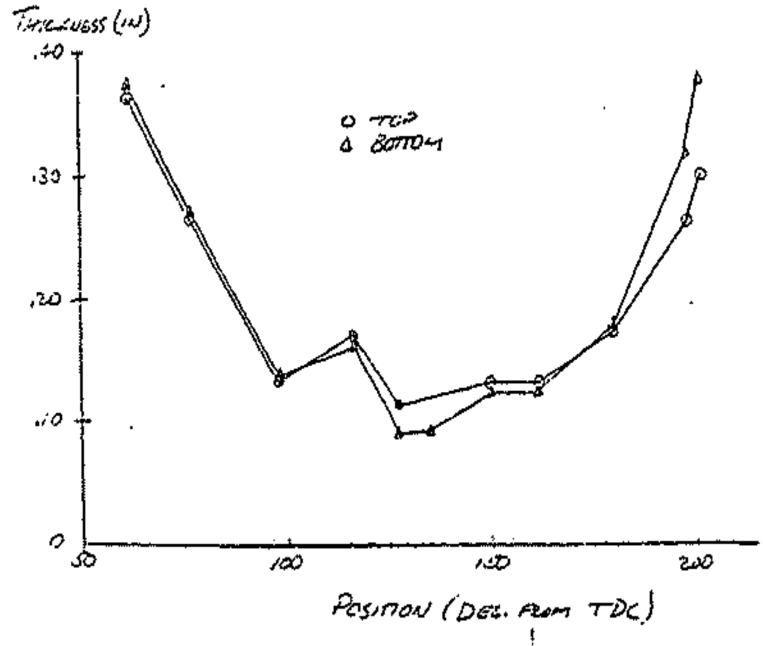
* POST TEST CALIBRATION OF SENSORS IN PROCESS

NOTE: ALL DATA ARE IN ΔP-PSI

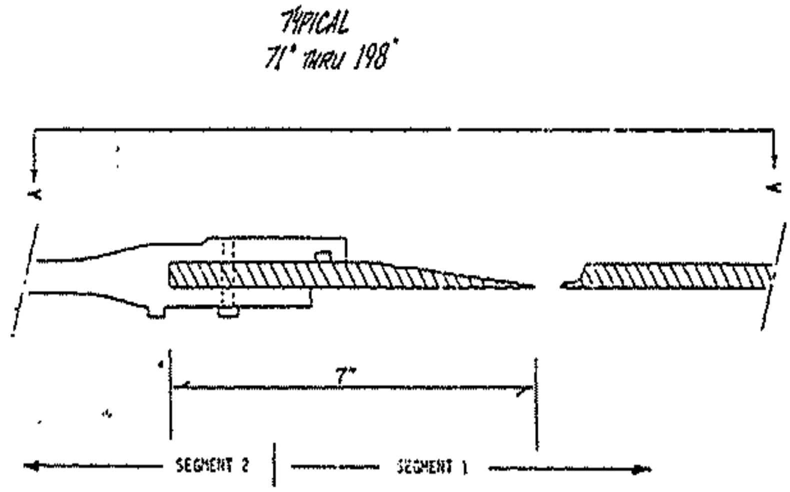
Overpressure Data

TAG	SUFX	BS/D	BS/M	R/P	REF_DIST	AC/D	AC/M	ACTUL_DIST	CONTRACTOR	DESCRIPTION
00040		204	12	A	1092.06	290	49	1479.04	MMC	OUTRIGGERS THRUSTERS
00130									MMC	AFT FUEL SKIRT IL
00143		67	40	D	404.26	58	23	385.15	MMC	CORE SKIN 32" X 3""
00149		30	35	E	301.55	33	24	154.04	MMC	CORE TANK SKIN 36" X 20"
00153		37	4	E	255.32	29	12	159.56	MMC	CORE SKIN 38" X 14"
00160		164	43	E	205.83	321	29	447.72	MMC	OX TANK AFT DOME
00162		154	43	E	205.83	321	29	447.72	MMC	INTER STAGE SECTION 5" LONG 2 5" WIDE
00163		160	26	E	108.53	320	28	350.04	MMC	RING P/N 80801A26021-009
00164		160	26	E	108.53	320	28	350.04	MMC	SKIN
00167		136	5	E	225.96	335	30	437.66	MMC	STRINGER
00178		290	27	I	325.17	346	8	436.16	MMC	FWD END FUEL TANK BARREL STAGE 1
00181		12	4	E	50.21	317	34	197.05	MMC	CORE WIRING & BRACKETS 12 PCS1 81600044201-210-1"X 3"
00182		12	4	E	50.21	317	34	197.05	MMC	CORE TANK STRINGER 7" X 1 1/2"
00183		348	15	E	100.46	306	37	146.93	MMC	CORE RELAY 3" X 4"
00184		348	15	E	100.46	306	37	148.93	MMC	CORE RELAY 3" X 4"
00187		99	7	I	655.14	250	19	834.50	MMC	CORE STRINGER 40" X 3"
00196		48	28	I	680.80	214	17	510.40	MMC	HOSE ASSY
00255		176	0	B	630.41	273	59	1043.39	MMC	ALUM PANEL 10"X14".
00268		170	70	B	507.04	270	20	1317.26	MMC	ALUM PLATE 10" X 10"
00321		267	16	B	81.42	287	26	425.32	MMC	ALUM TANK PART
00354		109	15	A	271.57	246	5	564.10	MMC	ROLL CONTROL ACT ARM
00359		115	54	A	337.08	244	41	636.97	MMC	AFT SKIRT CORE VEHICLE
00360		115	54	A	337.08	244	41	636.97	MMC	STG 1 AFT FUEL SKRT AFT FRAME & EQUIP TRUS/1081600X320
00361		115	54	A	337.08	244	41	630.97	MMC	ELECTRICAL BOXES
00362		109	26	A	344.90	241	14	627.98	MMC	ELECT POWER SUPPLY WITH MOUNT BKT (LOW LVL SENSOR).
00367		98	14	A	387.60	241	2	535.95	MMC	ELECT CONNECTORS/CIRCUITS
00369		52	4	A	265.20	241	14	501.48	MMC	INNER STG SKIRT
00396		70	12	A	302.98	230	33	421.37	MMC	STG 1 FUEL FWD SKIRT
00398		79	13	A	306.99	232	49	466.25	MMC	BOAT TAIL FLOOR
00399		79	14	A	162.95	223	4	442.68	MMC	FLANGED WITH ELEC CIRCUIT ALUM CAST 3" WIDE X 2"LONG
00405		999	99						MMC	ACTUATOR BUSHING MOUNTING BRACKET
00406		999	99						MMC	*SOUTH I BEAM CONNECTOR LS41455-012 MALCO
00407		999	99						MMC	AFT SKIRT STG 1 ACCOMPANIED BY OTHER SMALL PIECES.
00408		999	99						MMC	STG 1 AFT SKIRT
00417		0	0		0.00	0	0		MMC	STAGE 2 FUEL AFT DOME REF ITEM 433
00440		0	0		0.00	0	0		MMC	STAGE 2 FUEL AFT DOME, REF ITEM 433
00447		0	0		0.00	0	0		MMC	STRINGER FROM INTERSTAGE, REF ITEM 433
00448		0	0		0.00	0	0		MMC	RESISTOR BOX, REF ITEM 433
00449		0	0		0.00	0	0		MMC	STAGE 2 TANK BOTTOM DEFUSER, REF ITEM 433
00450		0	0		0.00	0	0		MMC	STG 2 MARMAN CLAMP COOLER/RSVR LOC NE OF 4E RET BASIN
00457		0	0		0.00	0	0		MMC	FUEL TANK BURST DISK (STAGE 2), LOC MIDDLE 4E RET BASI
00458		0	0		0.00	0	0		MMC	BOATTAIL FRAME LOC NE OF 4E RET BASIN
00462		0	0		0.00	0	0		MMC	STAGE 1 AFT RING FRAME LOC 15 S RET BASIN DECK
00463		0	0		0.00	0	0		MMC	BOATTAIL FRAME LOC 10' S RET BASIN DECK
00464		0	0		0.00	0	0		MMC	HYDRAULIC PUMP LOC 20' S RET BASIN DECK
00466		0	0		0.00	0	0		MMC	HYDRAULIC PUMP SPRING AND CAP PART OF 462
00467		0	0		0.00	0	0		MMC	BOATTAIL FRAME MEMBER LOC 9' N RET BASIN DRAIN

Sample Debris Log



THICKNESS (IN)
.40
.30
.20
.10
0
50
100
150
200
O TOP
Δ BOTTOM
POSITION (DEG. FROM TDC)



TYPICAL
71° THRU 198°
A
A
7"
SEGMENT 2
SEGMENT 1

DEPARTMENT OF THE AIR FORCE
USAF HOSPITAL, VANDENBERG (SAC)
VANDENBERG AIR FORCE BASE, CALIFORNIA 93437

19 May 1986

Memo for Colonel Knoll

Subject: Visit to Hollister Ranch

1. On 4 May 1986, we accompanied Colonel R. Knoll to Hollister Ranch. We met with some 15 to 20 residents of the area concerning the Titan accident on 18 April 1986. This visit was in response to Mrs. Boise's letter of 21 April 1986 (see attached).

2. Residents commented that a white cloud came rapidly down the coast after the explosion. Some noted skin and eye irritation immediately after being caught up in the cloud. A few complained of sore throats and a cough for several days thereafter.

3. Residents also expressed their concern about radiation exposure. We explained that there were no licensed sources on board but that there was a small quantity of magnesium-thorium structural material on board. We assured them that this was not a significant hazard and that the material was all recovered.

4. The results of our meeting left us with the impression that the residents were exposed to some agents evolved from the accident. Our opinion is that they were probably exposed to low levels of Al_2O_3 and HCl with a resulting mild irritation of skin and mucous membranes. No significant sequelae from the exposure should be anticipated.

5. Future launches, particularly those involving SLC-6, should consider the unusual dispersal patterns of toxic gases and aerosols formed during nominal and worst-case scenarios. The effects that were reported at Hollister as well as other reports from Jalama Beach and the Channel Islands imply that under certain conditions, toxic exposures could be experienced at extraordinary distances from Vandenberg.

Terry M. Morford

TERRY M. MORFORD, Major, USAF, BSC
Chief, Bioenvironmental Engineering Services

ALLEN J. PARMET, Major, USAF, MC
Chief, Aerospace Medicine

2 Atchs
1. Ltr, 21 Apr 86 - Mrs. Boise
2. Ltr, 9 May 86 - Mrs. Boise

Monday, April 21, 1986

Dear Commander,

Your rocket expesion last Friday, April 18th has infected my children. They were all exposed to the toxic cloud. They were not given the advantage of any warning or any information on the toxic material in the air surrounding them.

The location of this exposure is near point conception - on the west end of the Hollister Ranch. Two calls (that I know of) were made to Vandenberg Air Force Base with the questions "what is in the air? Is it dangerous to humans or animals?" The reply from VAFB was "we are not allowed to give any information."

Our first knowledge of the explosion was when a neighbor (also a resident on the Hollister Ranch) came by and told us he had seen the expesion and the huge orange cloud and was evacuating and urged us to do the same. Our children hurried to where other family members

were and warned them of the disaster. That is when they called VAFB and were given the no comment answer.

I understand the sheriff came to the front gate at the Hollister Ranch and declared the air safe at that location. that is 10-15 miles east of Pt. Conception and the air quality was entirely different where our children were exposed.

What I want to know is this:

<u>why</u> - couldn't we have had the priviledge of a warning - or some helpful information on the phone?

<u>what</u> - are the toxic affects of this chemical on human beings? was the rocket solar power or atomic powered?

<u>who</u> - do we deal with on this matter?

<u>who</u> - do we call when another disaster of this nature affects us?

<u>who</u> - is going to warn us next time?

I hope you will reply with answers to my questions.

Sincerely,

Martha T. Bowie
Parcel # 41
Hollister Ranch
Gaviota CA 931

our family members who were exposed to the toxic cloud are:

Beverly Boise Cossart
Elizabeth Boise Cossart (6 months old)
Kit Boise Cossart
Brenda Boise
Tom Tittle (boyfriend of Brenda's)
Ellen M. Boise
Philip T. Boise

I can give you names of more people that I am aware of who were also exposed if you request that information

May 9, 1986

Dear General Watkins,

Thank you for your prompt response to my letter after the rocket explosion. We are very grateful to Col. Knell, Dr. Parmet and Lt. Col. Mayford for coming to see us at the Hollister Ranch on Sunday afternoon, May 4th.

My conclusion is that we now have a line of communication going between us. We will work out a system where the residents of the Hollister Ranch will have prompt, correct information in the event of another mishap.

Thank you again for your part in helping us work together to solve this matter.

Sincerely,

Martha T. Boice
Parcel #41
Hollister Ranch
Gaviota, CA. 93117

USAF MISHAP REPORT
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H AFTO Form 781 Series

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L DD Form 365F, Weight and Balance Clearance Form F

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O Any Additional Substantiating Data Reports

P Statement of Damage to Private Property

Q Orders Appointing Investigating Board

R Diagrams (Fallout-Impact Area, etc.)

S Photographs

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE SYSTEMS COMMAND
ANDREWS AIR FORCE BASE DC 20334-5000

SPECIAL ORDER 12 May 1986

M-23

The Commander AFSC has appointed the following personnel to serve as members of the Safety Investigation Board for the purpose of investigating the Class A space mishap which occurred 18 April 1986 involving Titan 34D-9 at Vandenberg AFB CA. This duty will take precedence over all other duties. Authority: AFR 127-4, para 3-4.

Grade	Name	SSAN	Organization	Clearance
		PRESIDENT		
COL	NATHAN F. LINDSAY		ESMC/CC	Top Secret
		VICE PRESIDENT		
COL	AUBREY MCALPINE		SAF/SS	Top Secret
		PROPULSION GROUP		
COL	LARRY JACKSON		SD/YA	Top Secret
LT COL	AL BLAHO		AFCMD	Top Secret
	ROBERT GEISLER		AFRPL/DY	Top Secret
	WILBUR W. WELLS		AFRPL/MKB	Top Secret
		VEHICLE SYSTEMS GROUP		
COL	JAMES MANNEN		SD/DAAX	Top Secret
LT COL	ERIC E. SUNDBERG		HQ SPACECMD/DOT	Top Secret
MAJ	EDWIN A. BLANKINSHIP		SD/YG	Top Secret
MAJ	JOHN CUNNINGHAM		SD/YD	Top Secret
		LAUNCH OPERATIONS AND PROCESSING GROUP		
COL	GEORGE STETZ		6595 STG	Top Secret
LT COL	JERRY M. JOHNSON		6555 ASTG	Top Secret
CAPT	MIKE G. WOOLLEY		6555 ASTG	Top Secret

M-23

Grade	Name	SSAN	Organization	Clearance
	RANGE SYSTEMS REVIEW TEAM			
LT COL	WILLIE W. GRAY		ESMC/RO	Top Secret
LT COL	WILLIAM CHRISTENSEN		USAFSAM/EVK	Top Secret
MAJ	GERALD F. BIERINGER		ESMC/SE	Top Secret
MAJ	E. GEORGE WOLF, JR.		USAFSAM/EVH	Top Secret
	KENNETH L. KAISLER		ESMC/SEM	Top Secret
	LOUIS T. ULLIAN		ESMC/SEM	Top Secret
	SUPPORT TEAM			
COL	FREDERICK W. WEIL		WSMC	Top Secret
1LT	RICHARD F. MAFFEI (Recorder)		SD/YXD	Secret
	ADVISORS			
MAJ	BARRY L. RICHARD		SD/SE	Top Secret
	ALEX MCCOOL		Marshall Space Flight Center	Top Secret
	ROBIN STEVENSON		Aerospace Corp	Top Secret
	WILLIAM DRAKE		Aerospace Corp	Secret
	JOHN WILLACHER		Aerosaace Corp	Secret
	OTTO BENDER		Aerospace Corp	Secret
	MERRITT BIRKY		NTSB	None
	ROBERT MCGUIRE		NTSB	None

This special order revokes M-21, 28 April 1986.

FOR THE COMMANDER

OFFICIAL

DENIS ... LIN, Colonel, USAF
Director of Administration

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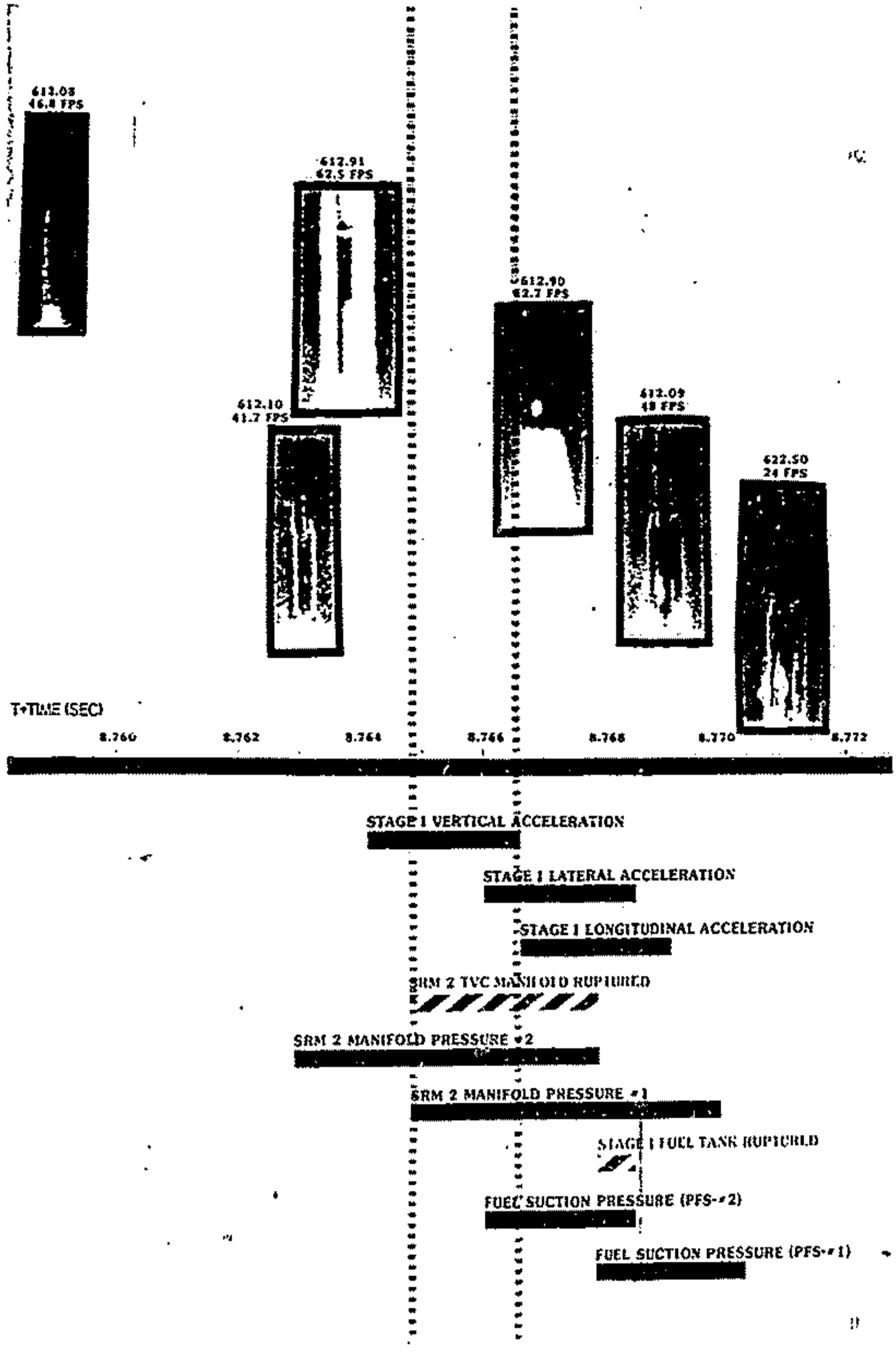

612.08
46.8 FPS
612.91
62.5 FPS
612.10
41.7 FPS
612.90
62.7 FPS
612.09
48 FPS
622.50
24 FPS
T+TIME (SEC)
8.760
8.762
8.764
8.766
8.768
8.770
8.772
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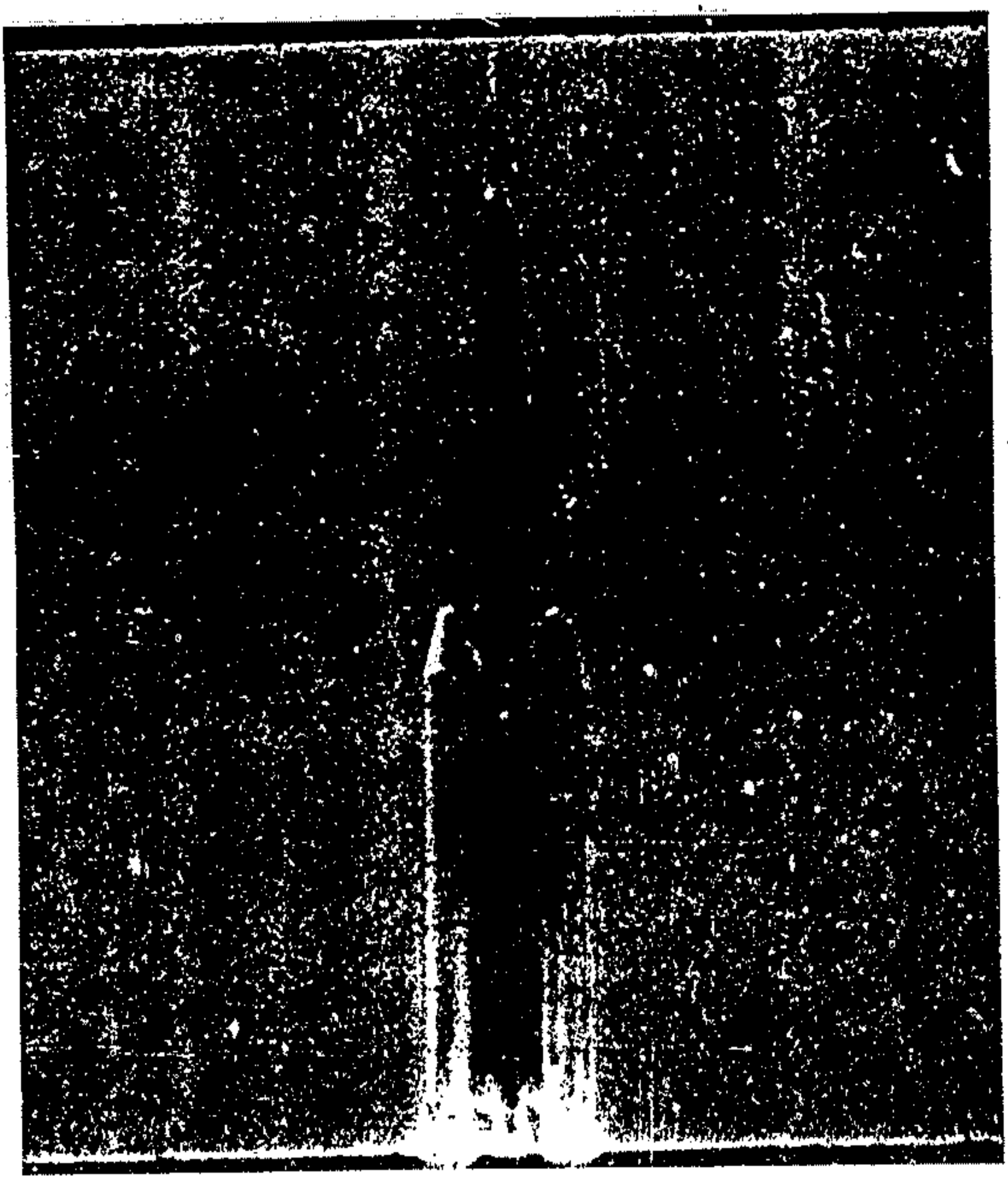
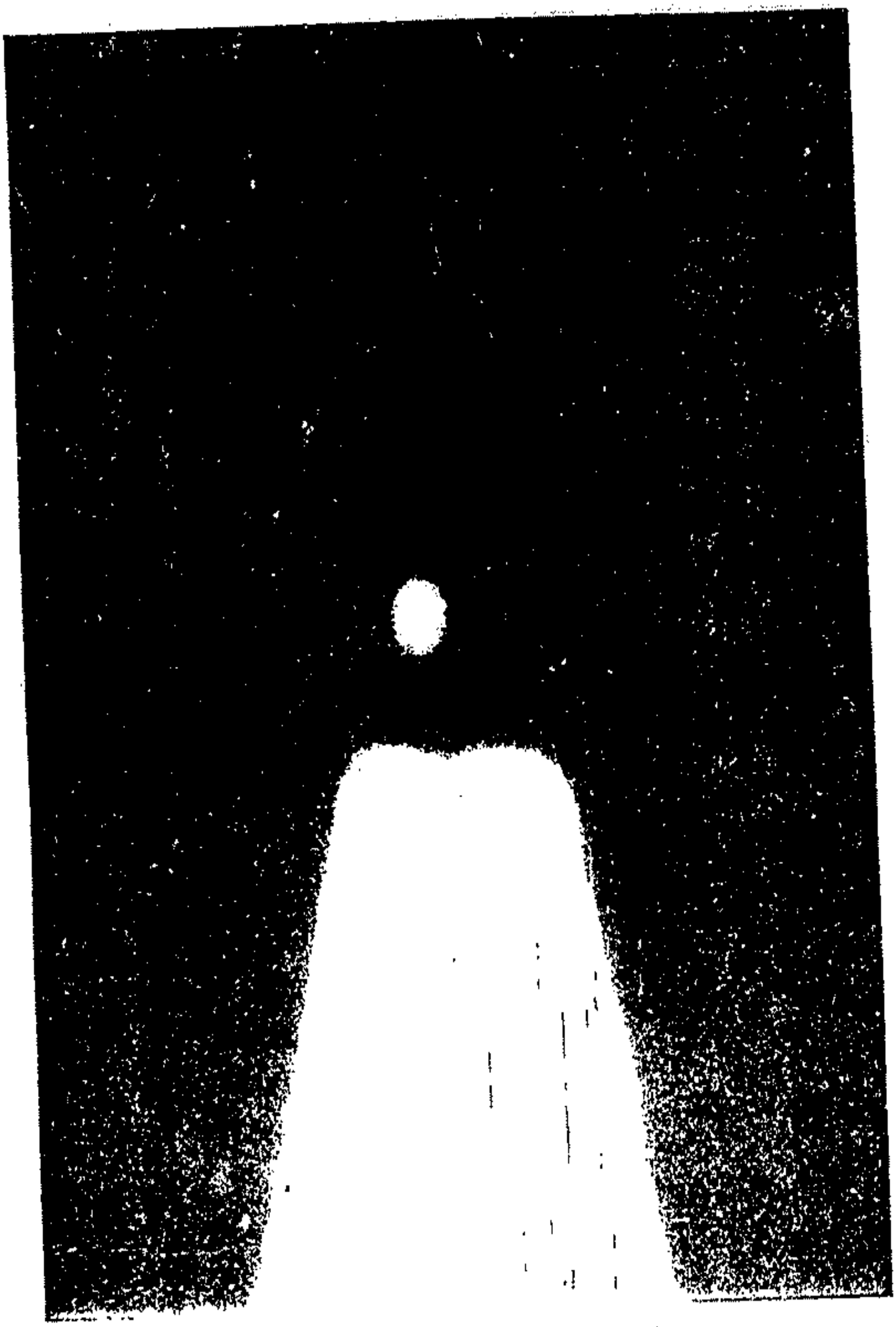
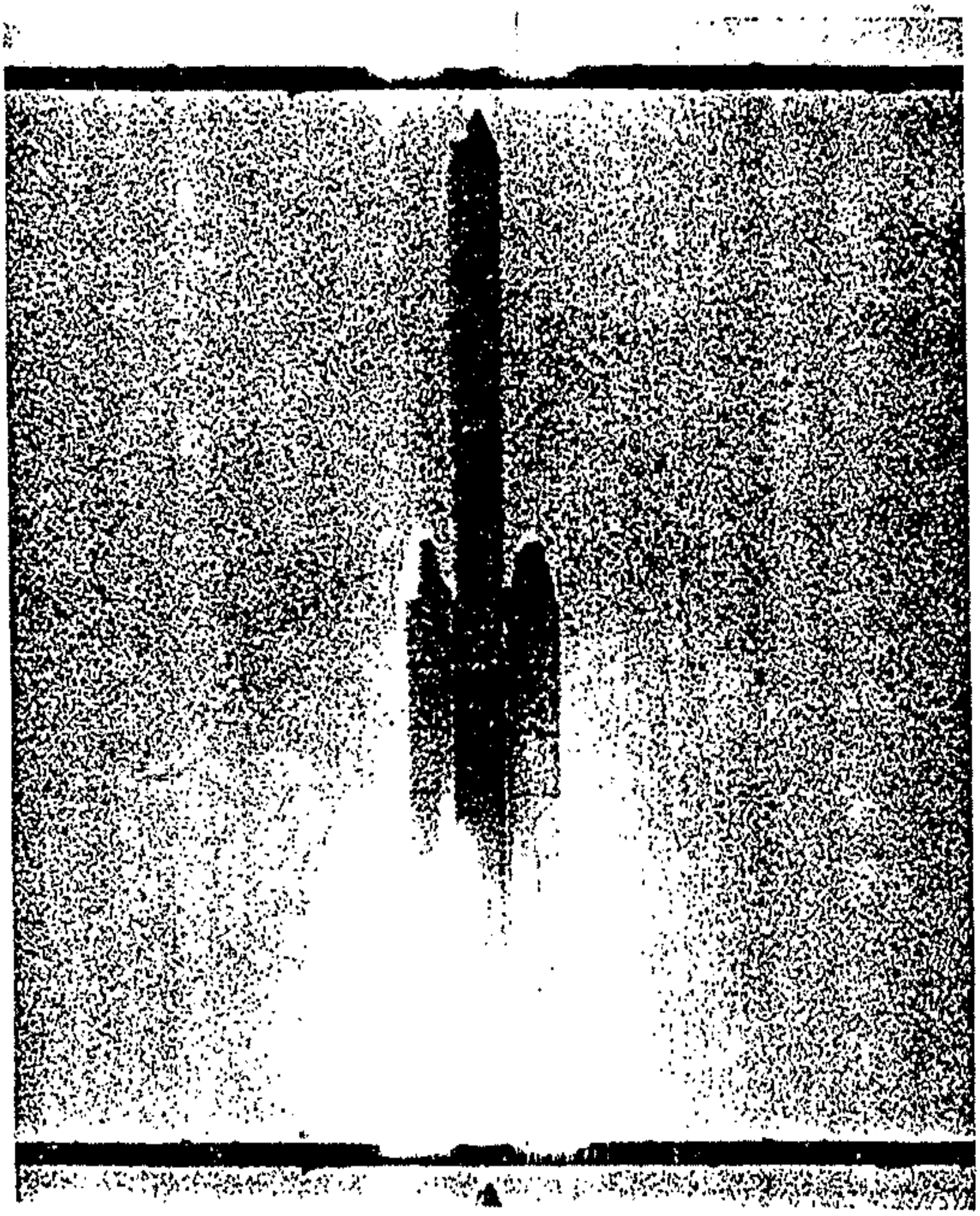
STAGE 1 LATERAL ACCELERATION
STAGE 1 LONGITUDINAL ACCELERATION
SRM 2 TVC MANIFOLD RUPTURED
SRM 2 MANIFOLD PRESSURE #2
SRM 2 MANIFOLD PRESSURE #1
STAGE 1 FUEL TANK RUPTURED
FUEL SUCTION PRESSURE (PFS-#2)
FUEL SUCTION PRESSURE (PFS-#1)

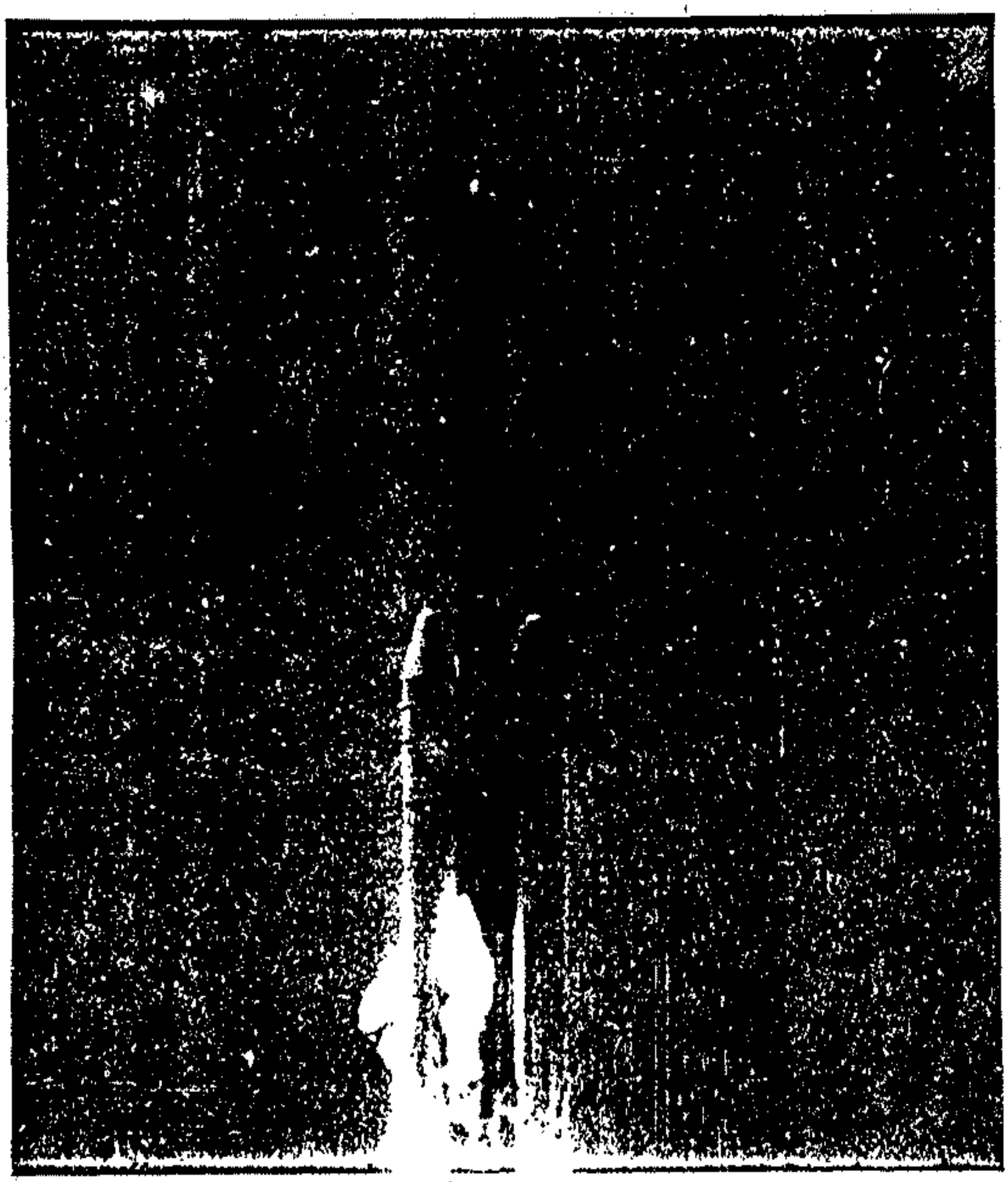


One Frame Prior to Event
T+8.729 Seconds
(Film 622.50, Frame -1)



S-3

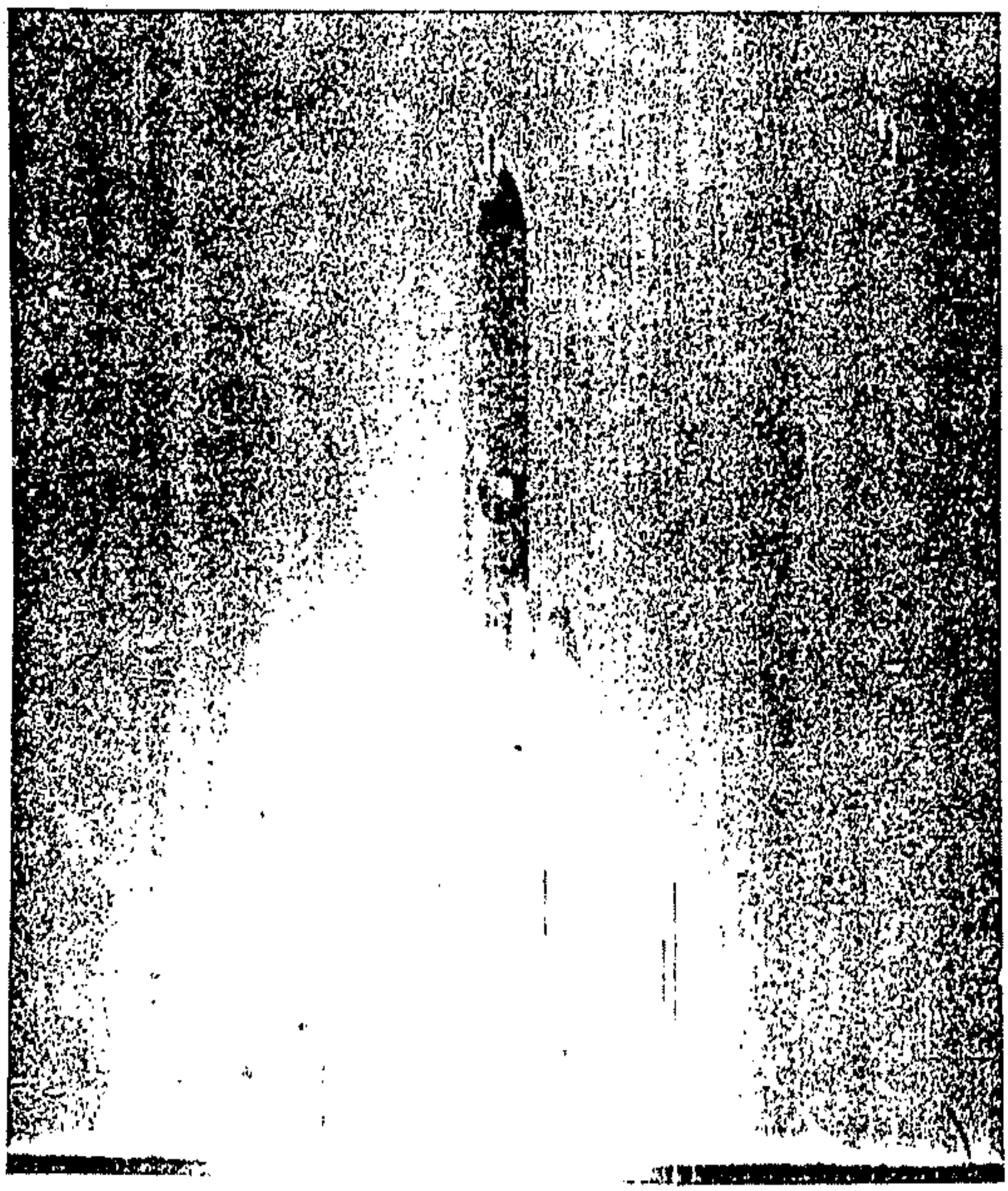




First Frame Showing Event
T+8.771 Seconds
(Film 622.50, Frame 0)

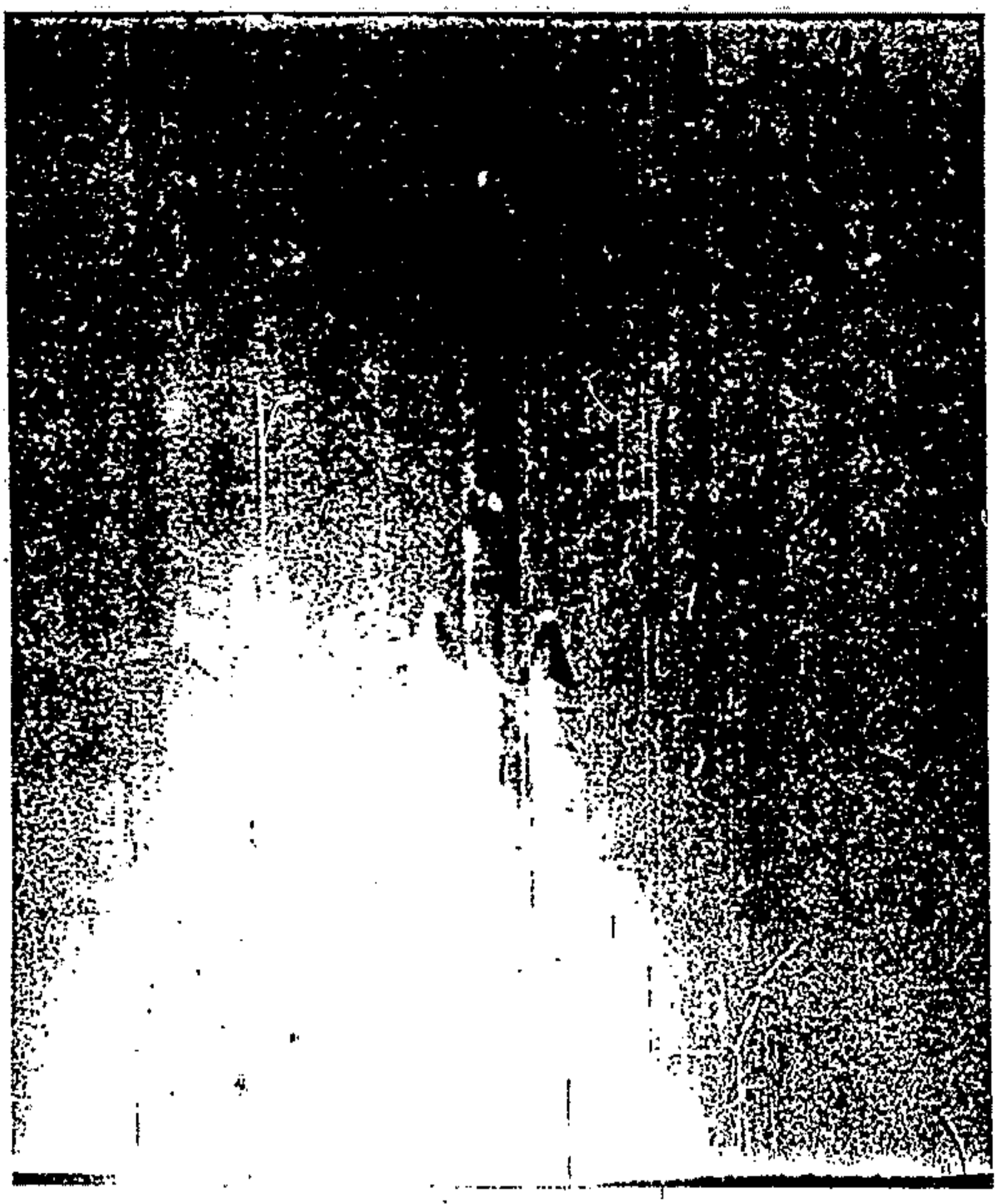
SRM-1, ISDS Destruct (612.10 Fm +13)

SRM-1, ISDS Destruct (612.10 Fm +14)



Fireball Expanding
T+8.812 Seconds
(Film 622.50, Frame +1)

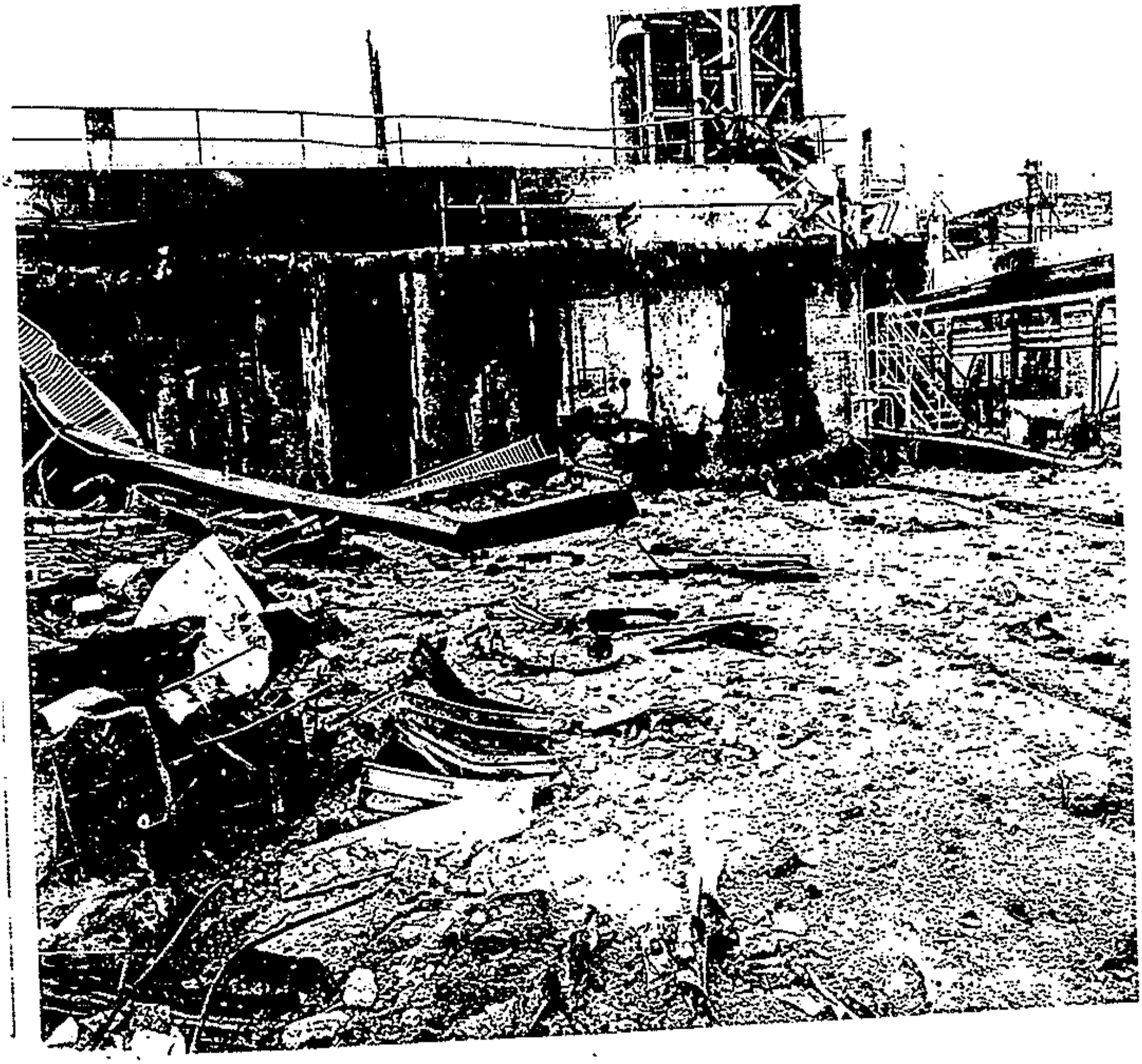
SRM-1, ISDS Destruct (612.10 Fm +15)

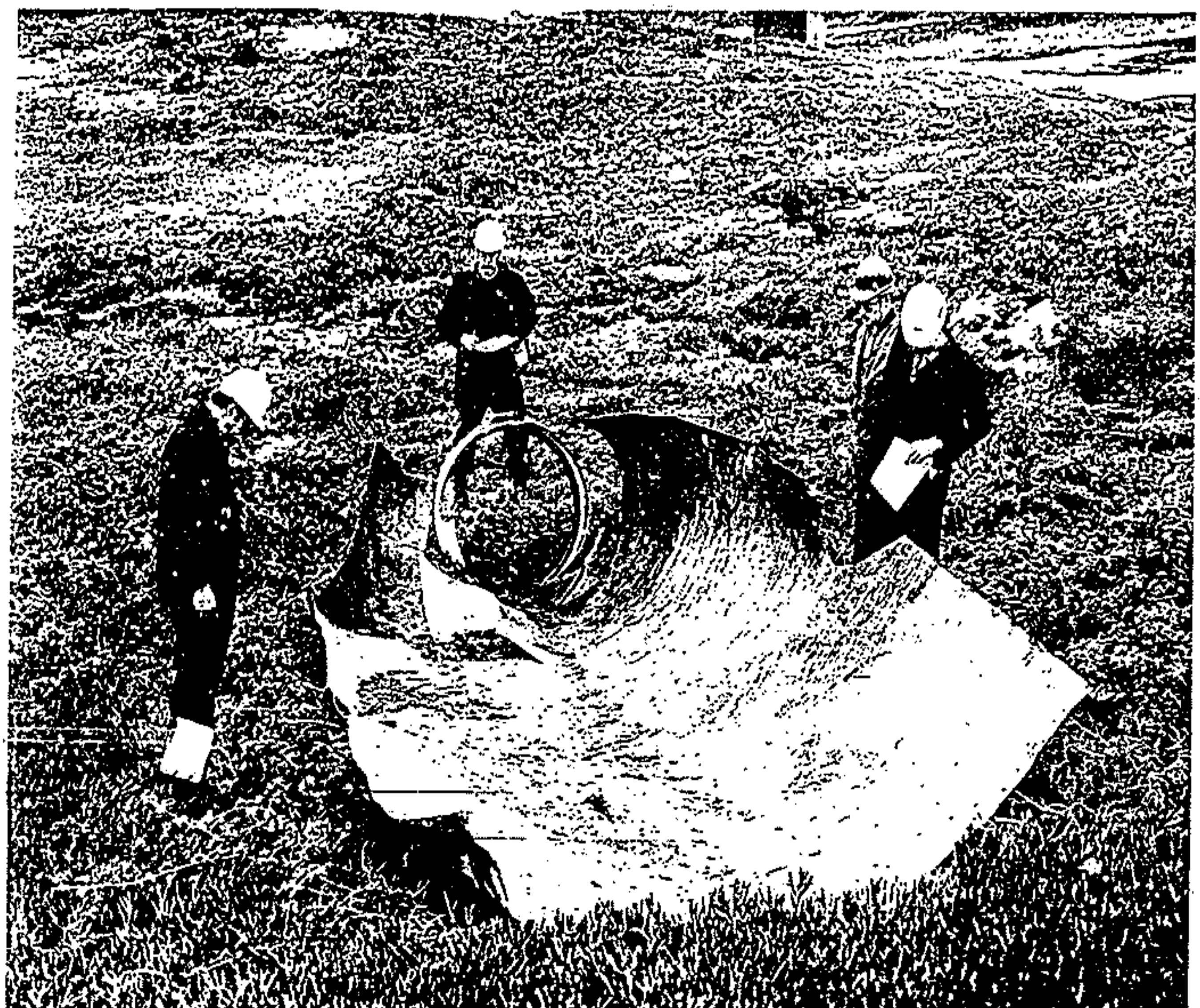


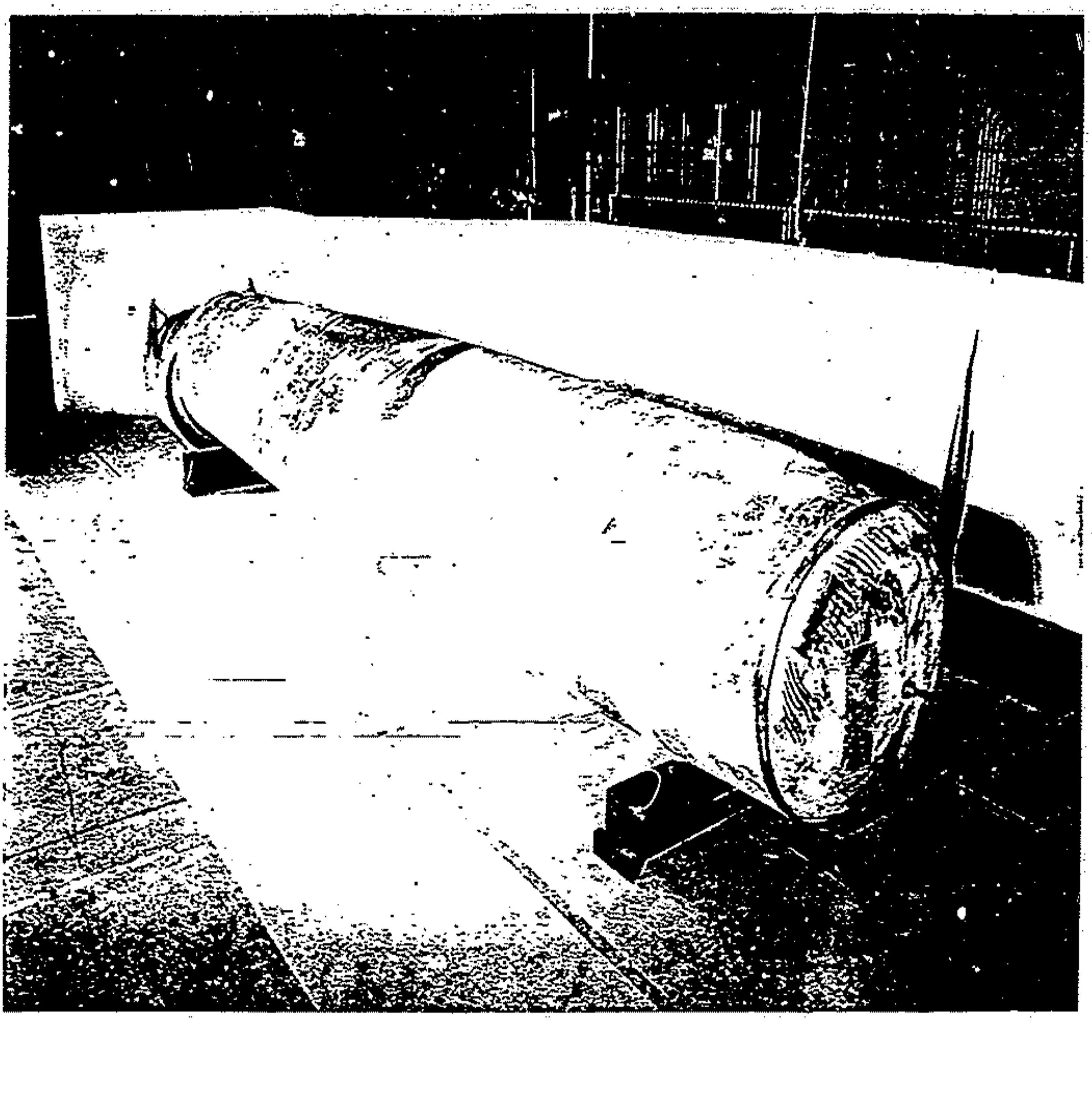
Fireball Expanding
T+8.854 Seconds
(Film 622.50, Frame -2)

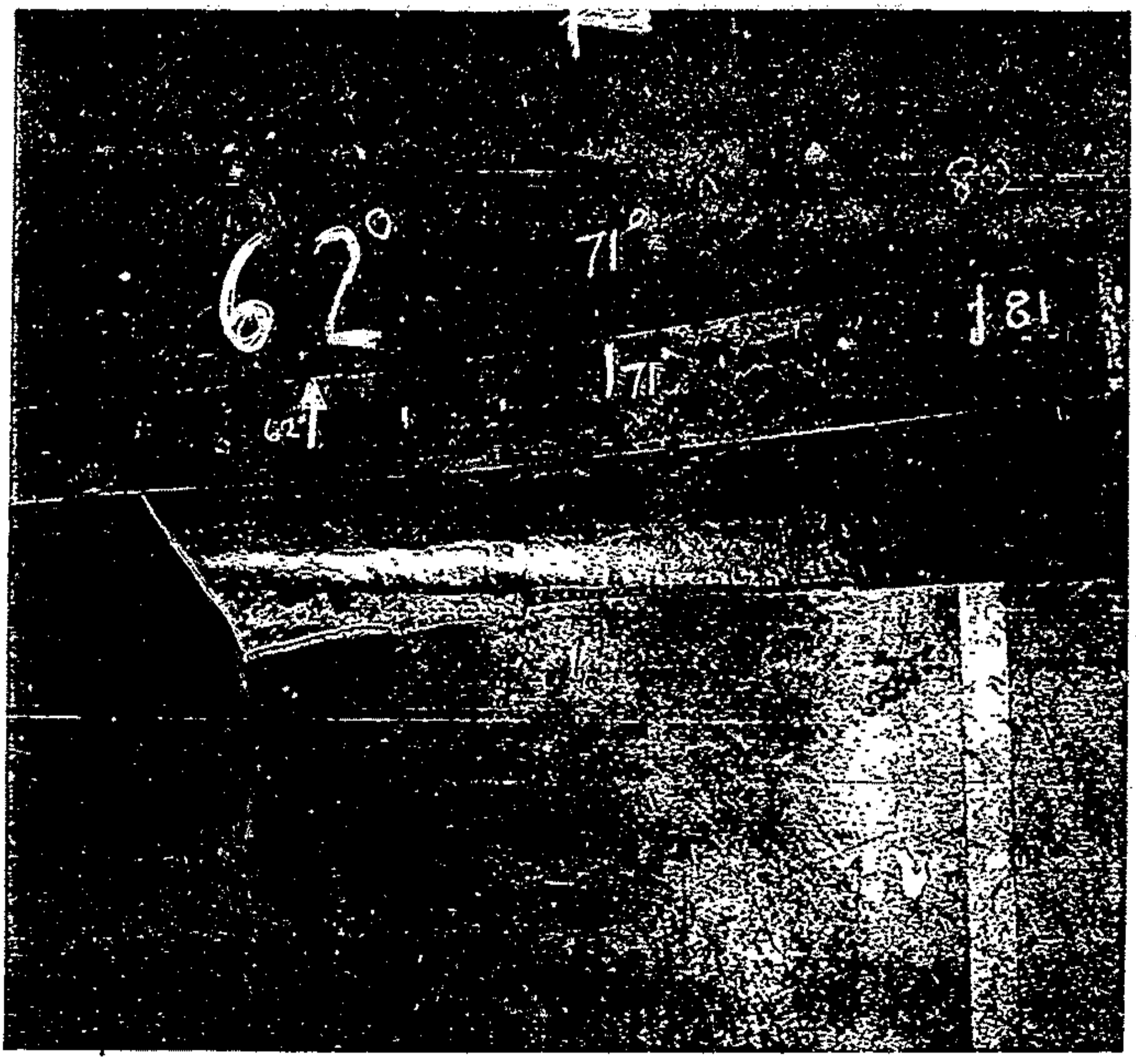
SRM-2 Motion (622.50, Fm +2)

S-12








62°
71°
81
71
62°